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NEW LATE CRETACEOUS AND EARLY TERTIARY PERISSITYIDAE (GASTROPODA) FROM THE PACIFIC SLOPE OF NORTH AMERICA

LouElla R. Saul

CONTENTS

ABSTRACT 1
INTRODUCTION 1
MATERIALS AND METHODS 2
OCCURRENCE 3
RELATIONSHIPS WITHIN PERISSITYIDAE 4
SYSTEMATIC PALEONTOLOGY 5
  Family Perissityidae 5
    Genus *Forsia* new genus 5
      Forsia lorda new species 7
      Forsia baia new species 8
      Forsia popenoei new name 10
    Genus *Nekewis* Stewart, 1927 11
      Nekewis marina new species 12
      Nekewis seidersi new species 12
    Genus *Heteroterma* Gabb, 1869 13
      Heteroterma trochoidea Gabb, 1869 13
      Heteroterma(?) *acrita* new species 14
    Genus *Pseudocymia* Popenoe & Saul, 1987 16
      Pseudocymia(?) *wardi* new species 16
    Genus *Christitys* Popenoe & Saul, 1987 16
      Christitys delta Popenoe & Saul, 1987 16
    Genus *Zinsitys* new genus 17
      Zinsitys meisteri new species 17
      Zinsitys edwilsoni new species 18
      Zinsitys anassa new species 20
      Zinsitys kingii new species 21
      ?*Zinsitys* sp. 21
ACKNOWLEDGMENTS 21
LITERATURE CITED 22
LOCALITIES CITED 24

NEW LATE CRETACEOUS AND EARLY TERTIARY PERISSITYIDAE (GASTROPODA) FROM THE PACIFIC SLOPE OF NORTH AMERICA

LouElla R. Saul[1]

ABSTRACT. Late Cretaceous Pacific Coast gastropods previously identified as *Hindsia nodulosa* (Whiteaves, 1874) constitute a new genus, *Forsia,* and are divided into three biostratigraphically significant species: *F. lorda* new species of Santonian age, *F. baia* new species of early Campanian age, and *F. popenoei* new name of mid-Campanian age. Gastropods previously identified as *Fusus kingii* Gabb, 1864, also constitute a new genus, *Zinsitys,* and are divided into four biostratigraphically significant species: *Z. meisteri* new species of Coniacian age, *Z. edwilsoni* new species of Santonian age, *Z. anassa* new species of early and mid-Campanian age, and *Z. kingii* (Gabb, 1864) of late Campanian age. *Forsia lorda* and *Zinsitys meisteri* are clearly related to *Perissitys cretacea* (Cooper, 1896), and these genera are placed in the family Perissityidae (Popenoe and Saul, 1987). *Pseudocymia*(?) *wardi* new species of Santonian age, *Nekewis marina* new species of early Maastrichtian age, and *N. seidersi* new species of late Maastrichtian age are described as perissityids. The genus *Heteroterma* Gabb, 1869, is delimited from more nearly complete specimens, and the new species *H.*(?) *acrita* is questionably included.

INTRODUCTION

This is the second part of a two part paper describing the neogastropod family Perissityidae (Popenoe and Saul, 1987). It discusses primarily two lineages, those of "*Hindsia nodulosa*" and "*Fusus*" *kingii,* and their relationships to other perissityids.

The first notice of the "*Hindsia nodulosa*" lineage is the description of *Fasciolaria nodulosa* Whiteaves, 1874, from British Columbia Nanaimo Basin deposits of Campanian age. Whiteaves (1879) later transferred that species to the genus *Hindsia,* which he placed in the Tritoniidae = Cymatiidae. The outer lip and the columella of "*Hindsia nodulosa*" have, however, the distinctive denticulations and pseudofolds of a perissityid, and a new genus, *Forsia,* is proposed for this lineage. The earliest *Forsia* species is of Santonian age and is very similar to Coniacian and Santonian species of *Christitys* (Popenoe and Saul, 1987). The geologically youngest species of *Forsia* resembles species of *Nekewis* (Stewart, 1927) in sculpture and shape, but differs in having a thicker inner lip and apertural denticulations.

Zinsmeister (1983) suggested that *Nekewis, Cophocara* (Stewart, 1927), and *Heteroterma* (Gabb, 1869) were all Tudiclidae, but they lack the fold or swelling on the columella and the rounded aperture typical of tudiclids. The confamilial association of *Heteroterma* and *Nekewis* with *Cophocara,* a lineal descendant of *Perissitys* (Popenoe and Saul, 1987), places *Heteroterma* and *Nekewis* in the Perissityidae. However, these genera lack the apertural characteristics of early perissityids, and their association remains tentative, dependent upon their postulated derivation from perissityids. *Nekewis* resembles *Forsia* of mid-Campanian age, but late Campanian intermediates between *Forsia* and the herein described early and late Maastrichtian *Nekewis* are absent.

Species from South America and New Zealand have been included in *Heteroterma* (e.g., Stewart, 1927; Finlay and Marwick, 1937) because of their similarity to *H. gabbi* Stanton, 1896, but *H. gabbi* is not congeneric with *H. trochoidea* Gabb, 1869, the type of *Heteroterma.* Both of Stanton's species, *H. striata* and *H. gabbi,* are closer to *Pyropsis* and belong in the Tudiclidae (Saul, in press).

The eponymous species of the second lineage, "*Fusus*" *kingii* Gabb, 1864, is based on a fragment from the Siskiyou Mountains, northern California, that is little more than a steinkern. Nonetheless, its distinctive elongate coiling and biangulate whorl have caused paleontologists to recognize "*Fusus*" *kingii* elsewhere (Whiteaves, 1879, 1903; White, 1889; Usher, 1952). The new genus *Zinsitys* is proposed for those species formerly included in "*Fusus*" *kingii.* The oldest species of this lineage is from the Coniacian east of Redding, Shasta Co., California, and is, as with other perissityid lineages, very similar to *Perissitys cretacea* (Cooper, 1896). Later species, such as "*Fusus*" *kingii* itself, which is of late Campanian age, have less in common with other perissityids of similar age, e.g., *Perissitys pacifica* Popenoe & Saul, 1987.

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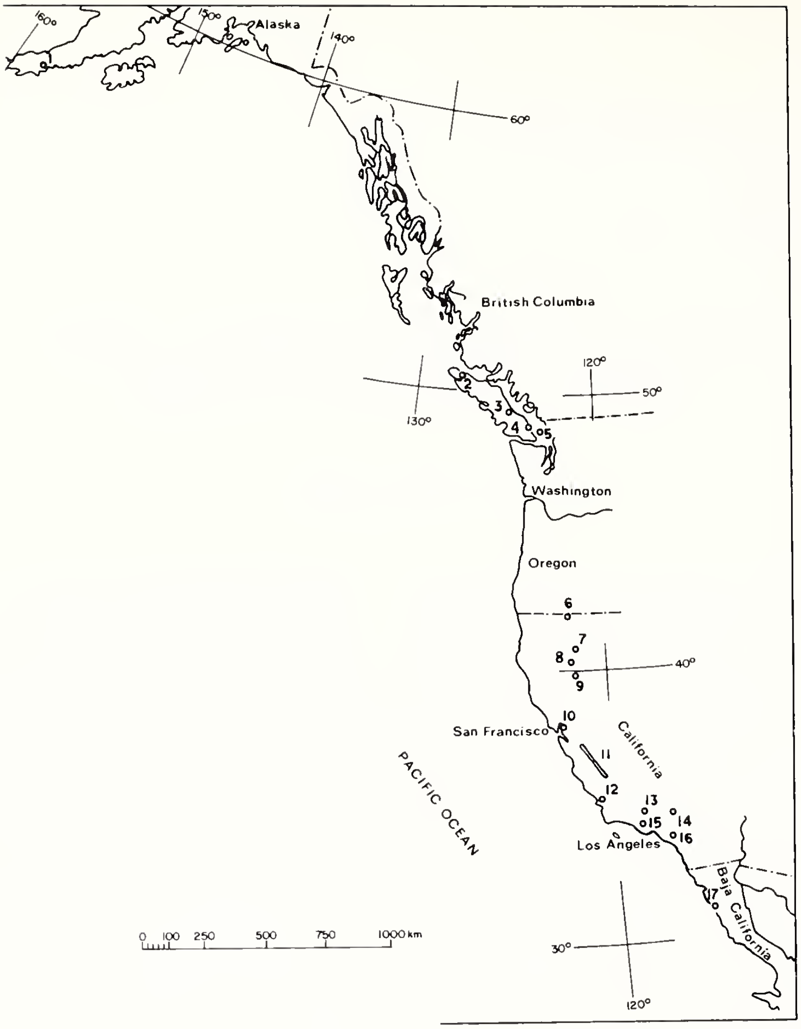


Figure 1. Index map to geographic occurrence of studied specimens. Localities are grouped into areas; the areas are numbered from north to south, and named places within each are are listed alphabetically. **1.** Alaskan Peninsula, Mt. Chiginagak area and Whaler's Creek. **2.** Suquash Basin near Port Hardy, Vancouver Island, British Columbia, includes Thomas Point. **3.** Comox, Vancouver Island, British Columbia, includes Brown's River, Denman Island, Hornby Island, and Trent River. **4.** Nanaimo, Vancouver Island, British Columbia, includes Benson (=Brannan) Creek, Departure Bay, Elkhorn Creek, Nanaimo River, Northwest Bay, and Protection Island. **5.** Sucia Island, San Juan Co., Washington. **6.** Siskiyou Mountains, Siskiyou Co., California and Jackson Co., Oregon, includes Cottonwood Creek. **7.** Redding, Shasta Co., California, includes Oak Run, Old Cow Creek, South Cow Creek, and Swede Basin. **8.** Antelope Creek, Mill Creek, and Tuscan Springs, Tehama Co., California. **9.** Chico Creek, Butte Co., California. **10.** Martinez and Pacheco, Contra Costa Co., California. **11.** East side of the Diablo Range from Stanislaus Co. south to Fresno Co., California, includes Charleston School Quadrangle, Laguna Seca Creek, Los Baños Creek, Ortigalita Creek and Peak, Panoche Creek, and Silver Creek. **12.** Lake Nacimiento, southern Santa Lucia Range, San Luis Obispo Co., California, includes Cantinas Creek and Dip Creek. **13.**Warm Springs Mountain, Los Angeles Co., California. **14.** Pinyon Ridge, Rock Creek, Valyermo area, Los Angeles Co., California. **15.** Simi Hills, Los Angeles and Ventura cos., California, includes Bell and Dayton canyons. **16.** Santa Ana Mountains, Orange Co., California. **17.** San Antonio del Mar, Baja California Norte, Mexico.

Indeed, Stewart (1927, p. 410) noted that "*F.*" *kingii* resembled a biangulate *Volutoderma* but lacked columellar folds and was not a volute.

Forms similar to both "*Hindsia nodulosa*" and "*Fusus*" *kingii* were present during the Late Cretaceous of Japan. Among plaster casts of undescribed Late Cretaceous Japanese gastropods sent by T. Kase is one apparently intermediate in shape and characteristics between "*F.*" *kingii* and *Surculites mathewsonii* Gabb, 1864. Thus, *Surculites,* which has been considered to be a turrid and ancestral to *Nekewis* (Hickman, 1976), may be a perissityid.

MATERIALS AND METHODS

Specimens upon which this study is based have been collected by paleontologists, geologists, students, and curious laypersons over the past century and a quarter. These specimens have been preserved at various institutions, some of them not immediately accessible to those studying Pacific Slope fossils. Therefore, considerable material,

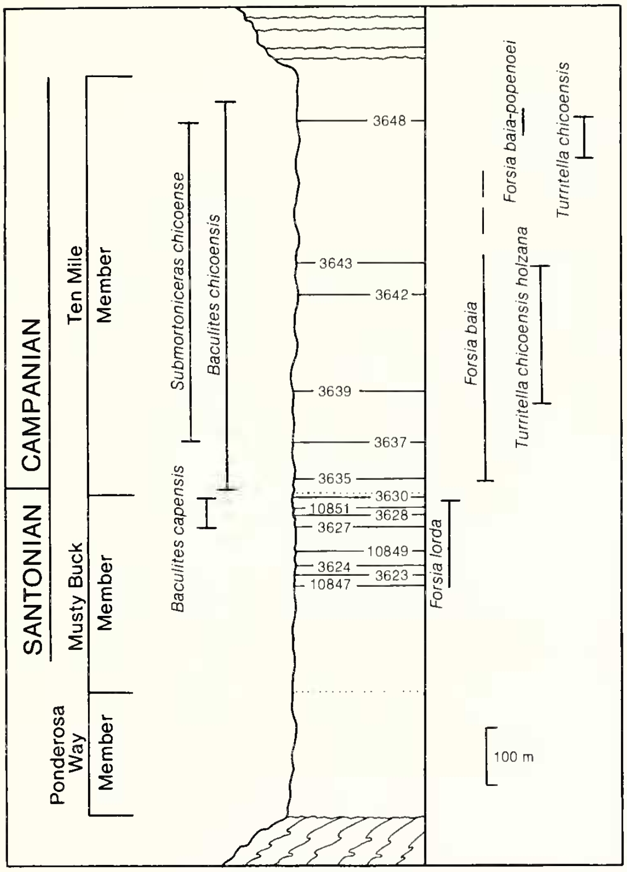


Figure 2. Occurrence of *Forsia* in the Chico Formation along Chico Creek, Butte Co., California. All of the plotted localities yielded *Forsia*. Column modified from Saul, 1983; Chico Formation members from Haggart and Ward, 1984.

including type material, was borrowed. Plaster casts have been made of these types so that Pacific Slope paleontologists will have adequate access to name-bearing specimens.

The matrix of most specimens studies is well-cemented sandstone that adheres to the shell. Notable exceptions are the Cowlitz Formation of Washington and certain localities in the Rosario Formation of southern and Baja California. The rest must have the matrix removed with diamond abrasive wheels. Fine details may be exposed under a low power microscope using a well-sharpened needle held in a pin vise. The shell, especially of the outer lip and anterior canal, has been supported by melting stick shellac and attaching the specimen to a cork. When the specimen is cleaned the shellac is removed by soaking in methanol.

Specimens from more than 70 localities were examined, but only those localities providing type material or other notable information are described.

Abbreviations used with locality and catalog numbers are: ANSP: Academy of Natural Sciences of Philadelphia; BCPM: British Columbia Provincial Museum, Victoria; CAS: California Academy of Sciences; GSC: Geological Survey of Canada; CIT: California Institute of Technology; CSMB: California State Mining Bureau; LACMIP: Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; LSJU: Stanford University; UCB: University of California, Berkeley (Department of Paleontology); UCBMP: University of California, Berkeley, Museum of Paleontology; UCLA: University of California, Los Angeles (Department of Earth & Space Sciences); UCR: University of California, Riverside (Department of Geological Sciences); USGS: United States Geological Survey; USNM: United States National Museum. CIT and UCLA collections are at the Natural History Museum of Los Angeles County. LSJU collections are at the California Academy of Sciences.

OCCURRENCE

Specimens studied have been found in deposits of Senonian through Early Tertiary age from Alaska to Baja California, Mexico. Figure 1 combines localities into numbered geographic areas referred to throughout this paper by the number in brackets. The best stratigraphic sequence of *Forsia* specimens is from the Chico Formation on Chico Creek, Butte Co. [9] (Fig. 2), and the evolution of the lineage through the Santonian and early Campanian is derived mainly from this sequence. Specimens from the Nanaimo Basin deposits [4], British Columbia, overlap the age range of the Chico specimens and extend the *Forsia* lineage through the medial Campanian. *Nekewis* appears in the early Maastrichtian of northern Baja California [17] and the Diablo Range [11] in Merced Co., California, and the later Maastrichtian near Lake Nacimiento, San Luis Obispo Co. [12]. *Nekewis* has been recognized in Paleocene deposits of the Simi Hills, Ventura Co. [15] (Zinsmeister, 1983) and in numerous Eocene and Oligocene sections in California, Oregon, Washington, and Alaska (Hickman, 1976).

Typical *Heteroterma* is a relatively rare form of Paleocene (late Danian–mid-Thanetian) age. Gabb's specimens came from the vicinity of Martinez, Contra Costa Co. [10], perhaps from the lower Vine Hill Sandstone. A few relatively complete specimens have been collected from the lower Santa Susana Formation in the Simi Hills, Ventura Co. [15].

Zinsitys has a longer geologic and a wider geographic range than *Forsia,* but it is usually represented by fewer specimens that have been recovered from greater stratigraphic and chronologic intervals. Its earliest appearance is in the Coniacian of the Redding area, Shasta Co. [7]. It occurs in the Santonian of the Redding area [7] and Antelope and Mill creeks, Tehama Co. [8], and the Haslam Formation of the Nanaimo Basin, Vancouver Island [4]. In the early Campanian it has been found from Whaler's Creek, Alaska Peninsula [1] south to the Santa Ana Mountains [16], California, and occurs in greatest abundance in the Cedar District Formation on Sucia Island, Washington [5]. Late Campanian *Zinsitys* have been found on Vancouver Island, British Columbia [2], in Siskiyou Co. [6], northern California, and in the Simi Hills [15] and Santa Ana Mts. [16] of southern California.

Geologic ranges of the species described in this paper are shown in Figure 3 with those of *Perissitys* spp., pertinent *Turritella* spp., and some ammonites.

Neither *Forsia* nor *Zinsitys* occurs in abundance. Specimens of *Forsia* are most abundant in the shallow-water (less than 40 m) sandstones of the Musty Buck Member of the Chico Formation and are uncommon in the finer-grained Ten Mile Member. *Forsia* is, however, recovered from fine-grained sandstones and siltstones of the Nanaimo Basin de-

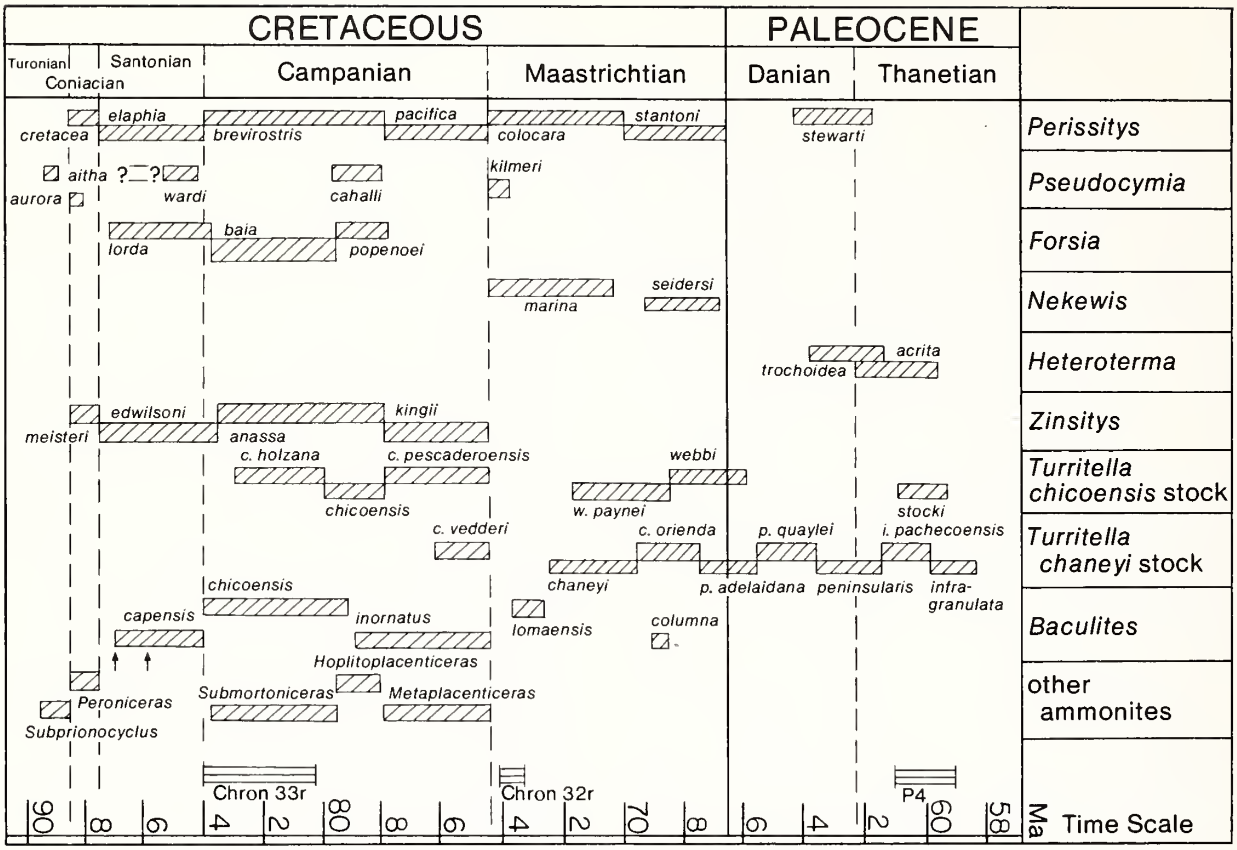


Figure 3. Geologic ranges of species described in this paper, *Perissitys* lineage, *Turritella chaneyi* and *T. chicoensis* stocks, and some ammonites fitted to the time scale of Palmer (1983) and Berggren et al. (1985). Arrows indicate approximately the range allotted to *Baculites capensis* by Haggart and Ward (1984) and Haggart (1984). *Turritella* zonation from Saul (1983), early Campanian reversed magnetozone, Chrone 33r, from Ward et al. (1983), and early Maastrichtian reversed magnetozone, Chrone 32r, from Bannon et al. (in press) as dated by Kent and Gradstein (1985).

posits, especially from the Cedar District Formation on Sucia Island [5]. Its earlier more common appearance in coarser-grained sediment and later relative abundance in fine-grained sediment suggests that *Forsia* may have migrated toward a more offshore habitat.

Zinsitys occurs in medium-grained to fine-grained sandstone and siltstone. It is a common faunal element only in the silts of the Cedar District Formation on Sucia Island [5]. Ninety percent of the studied specimens are from northern localities (northern California to Alaska); even so, the percentage of northern specimens is underrepresented. The studied specimens include some, not all, of the Sucia Island specimens in various collections, whereas every southern specimen found is included. If these collections reflect in some measure the former distribution of *Zinsitys,* it may have been a north temperate genus.

RELATIONSHIPS WITHIN PERISSITYIDAE

Well-founded relationships within the family Perissityidae include the sequences of species that comprise the *Perissitys* lineage, the *Forsia* lineage, and the *Zinsitys* lineage. Lineal relation of species ascribed to *Pseudocymia*(?), *Murphitys,* and *Christitys* is more inferential. Coniacian and early Santonian species of all six of the above genera share many characteristics. They are of moderate size and bucciniform shape, with fine to coarse spiral ribs and short but strong axial ribs about the whorl periphery. The growth line has an antispiral sinus adapical to the mid whorl. The aperture is elliptical and widest anteriorly. The outer lip is thickened, rimmed, and flared, especially from mid whorl to the anterior siphon. Characteristically inside the outer lip at mid whorl there is a strong denticle with a lesser one anterior to it. This set of denticles is just anterior to the antispiral sinus and at the posterior end of the outer lip flare. The denticles oppose a pseudofold or fold on the columella. A moderately strong tubercle (or set of tubercles) in conjunction with similar structures on the inner lip constricts the posterior end of the aperture. The inner lip is clearly demarked and in some species forms a pseudumbilicus with the siphonal fasciole at the anterior end of the anterior siphon. Medially on the columella there are two or three subequal pseudofolds or one or two folds.

Folds and pseudofolds do not differ in apertural view; both appear to be spirally elongate plicae on the columella. Folds spiral uninterruptedly on the columella of the teleoconch, but pseudofolds are short, extending less than a quarter turn into the shell interior and are absent within earlier whorls. Pseudofolds, like varices, are developed at growth halts, and shells that have not developed a thickened and denticulate outer lip do not show pseudofolds, but folds are present even though the outer lip has not been thickened.

Later Senonian representatives of these six genera diverge, and their Campanian species have fewer common characteristics: *Pseudocymia* becomes fusiform and pseudofolds are diminished; *Perissitys* becomes pyriform, loses pseudofolds and outer lip denticulations, and envelops the spire in an expansion of the inner lip callus; *Murphitys* remains bucciniform, retains folds and outer lip denticulations, thickens the outer lip, and roundly expands the inner lip; *Christitys* becomes shortly turriculiform, retains one fold and pseudofold and the outer lip denticulations; *Forsia* becomes turriculiform and retains pseudofolds and outer lip denticulations; *Zinsitys* becomes elongately fusiform, loses pseudofolds, and reduces outer lip denticulations.

Of these six genera, Coniacian species of *Pseudocymia*(?), *Perissitys*, and *Murphitys* have the greatest similarity of shape and sculpture. *Christitys*, *Forsia*, and *Zinsitys* have more angulate whorl profiles. Although *Christitys* and *Murphitys* have columellar folds, they differ in whorl profile and aperture, and the columellar folds are probably separately evolved. Except for the columellar fold of *Christitys*, the apertures of *Christitys*, *Forsia*, and *Zinsitys* are very similar, and *Christitys* and *Zinsitys* have in common their northern distribution and the shape and position of their bifid outer lip denticulation. The similarity of early Santonian *Forsia* to Coniacian and Santonian *Christitys* suggests the derivation of *Forsia* from *Christitys* despite the absence of a columellar fold in *Forsia*. In Figure 4, a question mark between the early perissityid radiation and *Pseudocymia aurora* reflects the need for further study of Turonian and earlier faunas.

Relationships diagrammed in Figure 4 suggest that early Senonian perissityid genera having columellar folds developed them from pseudofolds. If *Forsia* split from *Christitys*, the columellar fold of *Christitys* was again reduced to a pseudofold in *Forsia*, but *Murphitys* evolved stronger folds. Given that the similarity of the Coniacian and Santonian species indicates confamiliality, folds and pseudofolds appear to be transient features in this group of gastropods. Two lineages, *Perissitys* and *Zinsitys*, clearly show loss of pseudofolds. *Perissitys* has lost its pseudofolds by early Campanian (Popenoe and Saul, 1987), as has *Zinsitys* in the late Campanian. Had Stewart (1927, p. 410) been looking at *Zinsitys meisteri* rather than *Z. kingii*, the absence of columellar folds would have been less apparent. Loss of apertural excrescences in these genera provides precedence for their absence in such genera as *Nekewis*, *Heteroterma*, and *Surculites* that may have evolved from more typically endowed perissityids. *Nekewis* may be derived from *Forsia*, *Heteroterma* from *Christitys*, and *Surculites* from *Zinsitys* or a Japanese *Zinsitys*-like perissityid. Apparently perissityids rapidly diverged through phyletic transition into lineages of increasingly distinctive morphology. Those speciations that produced these lineages became the founding events of genera.

SYSTEMATIC PALEONTOLOGY

Phylum Mollusca Linnaeus, 1758

Class Gastropoda Cuvier, 1797

Order Neogastropoda Wenz, 1938

Superfamily Buccinacea Rafinesque, 1815

Family Perissityidae Popenoe & Saul, 1987

Genus *Forsia* new genus

TYPE SPECIES. *Forsia baia* new species.

DIAGNOSIS. Turriculate perissityids that have a long slender abaperturally flexed anterior canal. They are sculptured by spiral threads that are most prominent on the noded angulate periphery. The growth line is shallowly sinused on the ramp, opisthocline across the noded peripheral angulation, and broadly antisinused on the siphonal neck. The aperture is elliptical. The flared outer lip has a strong, rounded varix that bears within a tooth anterior to the posterior notch, two strong teeth at the periphery, and a variable number of denticles adjacent to the anterior siphonal canal. The inner lip is clearly demarked, of moderate width, and has a parietal ridge or row of small denticles and two strong parallel horizontal pseudofolds nearly opposite the two strongest teeth of the outer lip.

STRATIGRAPHIC RANGE. Santonian through Campanian.

DISCUSSION. Specimens of *Forsia* spp. have, in general, been referred to *Hindsia nodulosa* (Whiteaves, 1874), a species originally described as *Fasciolaria nodulosa*. Whiteaves later transferred it to the genus *Hindsia* "in the sense in which that genus is now accepted by most paleontologists" (Whiteaves, 1879). Because of the expanded varix-like shape of the outer lip he placed *Hindsia* in the "Tritoniidae" = Cymatiidae. The name *Hindsia* was first printed in a plate explanation in 1851 (A. Adams, pl. 10), but the paper describing the genus appeared in 1853 (A. Adams). Then, in that same year, H. and A. Adams (1853) decided that *Hindsia* was a junior synonym of *Nassaria* Link, 1807. *Nassaria* was disentangled from *Hindsia* by Dell (1967) who designated *Buccinum tranquebarica* Gmelin, 1790, as type of *Nassaria* Link, thus placing it in the synonymy of *Cantharus* Röding, 1798. A. Adams (1851) figured two species of *Hindsia*, *H. nivea* Pfeiffer and *H. bituberculatis* A. Adams, on his plate 10. Several workers had indicated that the one figured as *H. nivea* Pfeiffer was the type species, but all designations remained ambiguous until that of Dell (1967): "*H. niveum* Pfeiffer" = *Buccinum niveum* Gmelin, 1790 = *Nassa alba* Martini, 1780 = *Neptunea pusilla* Röding, 1798.

In whatever sense most paleontologists of 1879 would have recognized *Hindsia*, the name is not applicable to the lineage of "*Hindsia nodulosa* (Whiteaves)." Species of this lineage

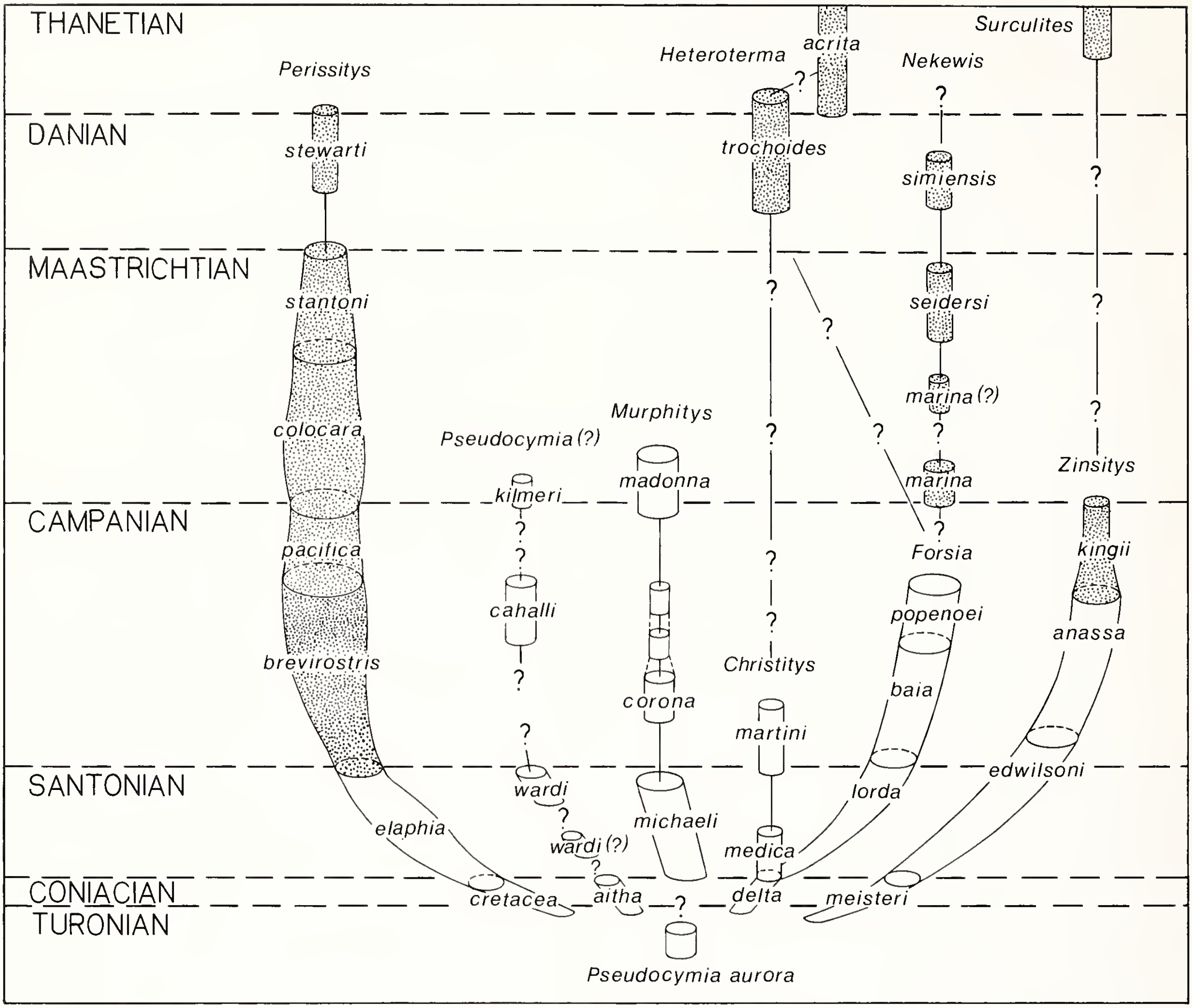
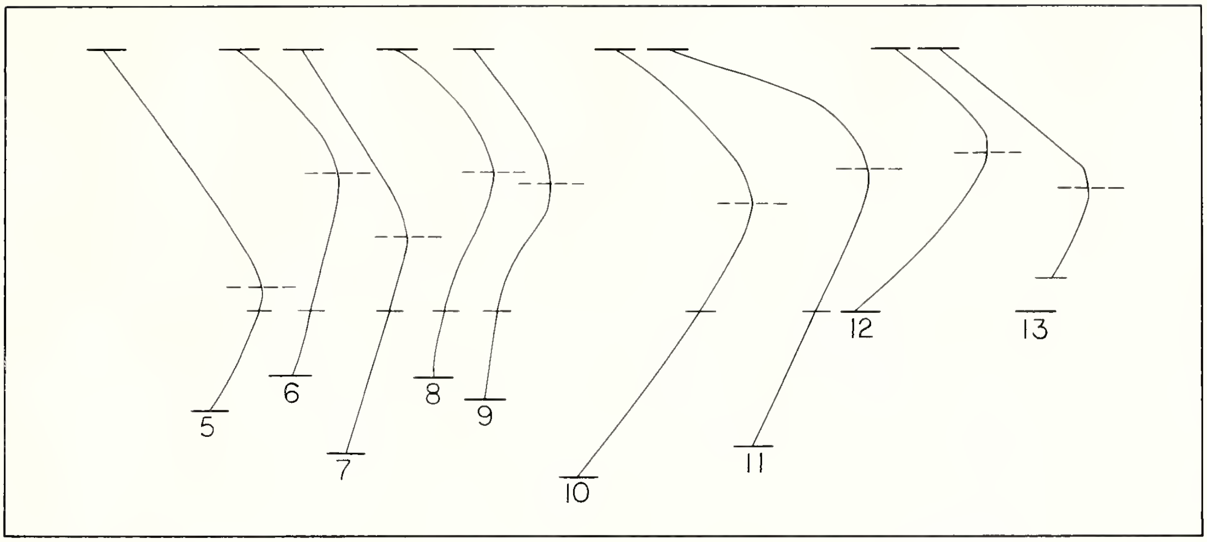


Figure 4. Hypothetical phylogenetic relationships of eight perissityid genera. Fatter segments represent availability of more specimens for study (not to scale). Stippled segments belong to species lacking folds or pseudofolds on the columella.

differ from bucciniform *Hindsia* with its roundish aperture, the outer lip of which is varixed and lirate but not flared, and its anteriorly plicate and posteriorly wrinkled columella. *Forsia* is fusiform, has an elongate, almost trapezoidal aperture, the outer lip of which is varixed and flared. The outer lip and the columella have the distinctive, medially positioned lip denticulations and pseudofolds of a perissityid.

Forsia resembles the cymatiid *Charonia*? *univaricosum* (Wade, 1926) (Sohl, 1960, p. 128, pl. 18, fig. 44), of Maastrichtian age, a species with an anterior canal more suggestive of *Sassia* Bellardi, 1872, than of *Charonia* s.s. *Forsia* also resembles Tertiary *Sassia*, but both *C.*? *univaricosum* and *Sassia* spp. have a rounder whorl profile, a rounder aperture, weaker apertural denticulations, and less flare to the outer lip.

The type species of the bicarinate Late Cretaceous cymatiid, *Tintorium* Sohl, 1960, *T. pagodiforme* Sohl, 1960, has a relatively higher spire and much shorter anterior canal than *Forsia* spp. *Tintorium nodulosum* (Stoliczka, 1867, p. 137, pl. 11, figs. 18, 18a) from India, has more nearly the proportions of *Forsia* but a rounder whorl profile, and lacks the apertural armaments. *Hindsia exima* Stoliczka, 1867 (p. 135, pl. 11, figs. 15, 16), also from India and of probable Maastrichtian age, is more bucciniform than *Forsia* and its peripheral sculpture is not as strong relative to that on ramp and base. It resembles *Murphitys*. *Murphitys* is more bucciniform than *Forsia*, has a more expanded inner lip, and folds on its columella. *Serrifusus* Meek, 1876, is similar in shape, sculpture, and bend of anterior canal, but is noticeably bicarinate and lacks pseudofolds on the columella. "*Serri-*



Figures 5–13. Comparison of posterior portion of growth lines of species of *Forsia, Nekewis,* and *Heteroterma* from camera lucida tracings adjusted to uniform distance between posterior suture and periphery. Heavy lines indicate posterior and anterior sutures, light line indicates periphery, and dashed line indicates inflection point of posterior sinus. **5,** *Forsia lorda* new species; **6,** *F. baia* new species; **7,** *F. baia–popenoei* intergrade; **8,** *F. popenoei* new name from Sucia Island, Washington; **9,** *F. popenoei* new name from Simi Hills, California; **10,** *Nekewis marina* new species; **11,** *N. seidersi* new species; **12,** *Heteroterma trochoidea* Gabb, 1869, periphery and suture coincide; **13,** *H.*(?) *acrita* new species, the periphery is anterior to the suture.

fusus" *vancouverensis* Whiteaves, 1879 (p. 119) [="*S.*" *joaquinensis* Anderson, 1958 (p. 171)] is not a *Serrifusus,* and its growth line and aperture suggest that it may belong to the Trichotropidae. *Forsia* lacks the great expansion of callus up onto the spire, is less pyriform, has a higher spire, and more angular profile than *Perissitys. Forsia* is most similar to *Christitys,* but has pseudofolds whereas *Christitys* has a fold and a pseudofold on the columella. *Forsia* may have evolved from *Christitys* near the Coniacian–Santonian boundary (Fig. 4).

Nekewis resembles *Forsia* but lacks the columellar pseudofolds and outer lip denticulations and has a thinner inner lip. Both have a long, twisted, and fasciolate anterior canal that is shallowly notched, abrupt peripheral nodes enhanced by strong spiral ribs, an undulose, collared suture, a broad, concave shoulder slope and concave base, and a growth line (Figs. 5–13) with a broad shallow sinus on the ramp.

The genus comprises *Forsia lorda, F. baia,* and *F. popenoei* [="*Hindsia nodulosa* (Whiteaves)"]. "*Fusus*" *volutodermoides* Nagao, 1939, may also belong here.

ETYMOLOGY. The genus name is from Anglo-Saxon, *fore,* preceding in time and place and is of feminine gender.

Forsia lorda new species

Figures 5, 14–27

DIAGNOSIS. Slender *Forsia* with a long, bent siphonal neck that has a well-developed siphonal fasciole and a pseudumbilical chink near the anterior end. Two peripheral spiral ribs are much stronger than the spiral threads that cover the shell.

DESCRIPTION. Shell of small to medium size, fusiform, tall and slender for the genus, with slightly turriculate spire of about five whorls and long flexed anterior canal; protoconch large, consisting of 1–1½ whorls; height of spire is about equal to diameter at periphery; anterior siphonal neck more than ⅓ of shell length, at angle of 45° to columellar axis, bearing well-developed fasciole and elongate pseudumbilical chink; profile of last two whorls concave on the ramp, prior whorls slightly convex; peripheral angulation accentuated by two strong spiral cords and made nodose by short, blunt, axial ribs; suture just anterior to abapical strong spiral cord; growth line gently and regularly concave on the ramp and slightly opisthocline across the periphery to the fasciole; outer lip flaring strongly and thickened by varix.

Overall sculpture of spiral ribs beginning on first post-nuclear whorl, nearly equal in width to interspaces on first two whorls, half as wide as interspaces on last whorl, number about doubled by intercalation; fine axial ribbing beginning on second post-nuclear whorl, strongest at periphery, stronger on third whorl but halved in number, about 13 on last whorl; adapical of peripheral pair of cords reduced in strength to that of other spirals on last half of ultimate whorl, but coincidentally strengthened abapical spiral maintains pair of peripheral spirals.

Aperture elongate, narrow, sharply elliptical; outer lip bearing one or two denticles near the posterior end, two strong teeth at the periphery alternate to external spiral cords, and one weaker tooth just below; inner lip clearly demarked, widest posteriorly, narrowing gradually anteriorly, with strong posterior parietal ridge, two strong, horizontal pseudofolds just anterior to the midpoint, and two to three denticles bordering the anterior canal.

HOLOTYPE. UCLA 39441.

PARATYPES. UCLA 39442 from UCLA loc. 3624, 39443 from CIT loc. 1017 = LACMIP loc. 10849, 39445 from UCLA loc. 3627, 39447 from CIT loc. 1016 = LACMIP loc. 10847; LACMIP 7586 from UCLA loc. 3624, 7587 from LACMIP loc. 10787, 7588 from LACMIP loc. 10786, 7589 from UCLA loc. 4217.

TYPE LOCALITY. UCLA loc. 3624, Chico Creek, Butte Co., California [9].

DIMENSIONS. Of holotype, height 35.6 mm, diameter 14.0 mm, height of spire 12.2 mm.

DISTRIBUTION. Musty Buck Member of the Chico Formation on Chico Creek [9]; Kingsley Cave Member of the Chico Formation on Mill and Antelope creeks [8]; Members V and VI (Popenoe, 1943) of the Redding Formation, Redding area [7], California.

GEOLOGIC AGE. Santonian.

REMARKS. More than 50 specimens of this species have been recovered from the Chico Formation in Tehama and Butte cos. [8, 9], California. The species resembles *Christitys delta* Popenoe & Saul, 1987 (Figs. 92, 93), and *C. medica* Popenoe & Saul, 1987, in growth line and sculpture but has two pseudofolds rather than a fold and a pseudofold on the columella, two peripheral denticulations within the outer lip rather than a bifid tooth, and is more elongate. Its long twisted anterior canal is distinctive, and it is the slenderest *Forsia.* It has the least turriculate spire, the posterior sinus inflection point of its growth line nearest the periphery, and the greatest contrast in the strength between the peripheral ribs and those on the ramp and base. Its resemblance to *Christitys delta* suggests derivation from that species.

Forsia lorda resembles *Cantharus occidentalis* Gabb, 1864 (Murphy and Rodda, 1960, p. 845, pl. 102, fig. 1), of Cenomanian age in shape of spire and body whorl, but *F. lorda* is less evenly ribbed and has apertural decorations that are lacking in *C. occidentalis.*

"*Fusus*" *volutodermoides* Nagao, 1939 (p. 231, pl. XXII, fig. 5; Hayami and Kase, 1977, p. 64, pl. 8, fig. 6), is similar to *Forsia lorda* in shape, sculpture, and age (Coniacian or Santonian, *fide* Hayami and Kase, 1977), but Nagao found the columella "apparently smooth." "*Fusus*" *volutodermoides* appears to be somewhat shorter spired than *F. lorda* and to have a less concavely sloping ramp.

ETYMOLOGY. The specific name is from Greek, *lordos,* bent backward, referring to the long bent anterior canal of this species.

Forsia baia new species

Figures 6, 28–35

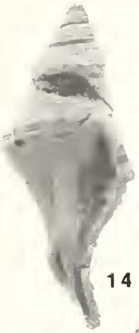
DIAGNOSIS. *Forsia* with a moderately long, bent siphonal neck, which has a well-developed siphonal fasciole and a short pseudumbilical chink near the anterior end. Three spiral ribs are stronger on the angulate periphery than are the spiral riblets that cover the shell.

DESCRIPTION. Shell of medium size, subfusiform with turriculate spire of about four whorls and flexed anterior canal; protoconch large, paucispiral consisting of 1–1½ whorls; height of spire is 72% of diameter at periphery; anterior siphonal neck less than ⅓ of shell length, bent near midlength at angle of 35° to columellar axis, bearing fasciole and short pseudumbilical chink; profile of last two whorls concave on the ramp, prior whorls convex; peripheral angulation accentuated by three strong spiral cords and made nodose by short blunt axial ribs; suture touching the most anterior of the three strong cords; growth line gently and regularly concave on the ramp and slightly opisthocline across the periphery to the fasciole; outer lip flaring and thickened by varix.

Overall sculpture of spiral ribs beginning on first postnuclear whorl, wider than the interspaces on first whorl, half

⟶

Figures 14–56. *Forsia* spp., arrow on apical views pointed at aperture. **14–27,** *Forsia lorda* new species, **14–18,** UCLA 39441 from UCLA loc. 3624, holotype, **14,** aperture ×1¼, **15,** back ×1¼, **16,** labral ×1¼, **17,** ablabral ×1¼, **18,** apical ×2; **19,** LACMIP 7586 from UCLA loc. 3624, paratype, axial section ×1½ showing absence of folds on columella; **20, 21,** UCLA 39443 from LACMIP loc. 10849 [=CIT 1017], paratype, **20,** aperture ×1½; **21,** labral ×1½; **22,** LACMIP 7588 from LACMIP loc. 10786 [=CIT 1005], juvenile paratype, aperture ×2; **23,** LACMIP 7587 from LACMIP loc. 10787 [=CIT 1006], "adolescent" paratype, aperture ×2; **24, 25,** UCLA 39445 from UCLA loc. 3627, paratype with complete outer lip, **24,** aperture ×1½, **25,** labral ×1½; **26, 27,** LACMIP 7589 from UCLA loc. 4217, paratype, **26,** back ×1½, **27,** ablabral ×1½. **28–35,** *Forsia baia* new species, **28–32,** UCLA 39452 from UCLA loc. 3637, holotype, **28,** aperture ×1, **29,** back ×1, **30,** labral ×1, **31,** ablabral ×1, **32,** apical 1½; **33,** LACMIP 7590 from UCLA loc. 3637, paratype, axial section showing pseudofolds in the aperture but absence of folds within the spire ×1; **34, 35,** UCLA 39454 from UCLA loc. 3643, paratype, **34,** aperture ×1½, **35,** labral ×1½. **36–56,** *Forsia popenoei* new name, **36–37** GSC cat. no. 5766a from Protection Island, B.C., paratype, **36,** back ×1¼, **37,** ablabral ×1¼; **38–41,** GSC cat. no. 5766 from Nanaimo River, B.C., holotype, **38,** ablabral ×1¼, **39,** aperture ×1¼, **40,** back ×1¼, **41,** labral ×1¼; **42–46,** UCLA 39462 from UCLA loc. 3648, hypotype, **42,** labral ×1, **43,** ablabral ×1, **44,** apical ×1½, **45,** aperture ×1, **46,** back ×1; **47–49,** BCMP 1183 from Sucia Island, Washington, hypotype, **47,** aperture ×1, **48,** back ×1, **49,** labral ×1; **50,** UCLA 39467 from LACMIP loc. 10448 [=CIT 1402], hypotype, aperture ×1, helicocone crushed but anterior siphonal canal complete; **51–53,** UCLA 39471 from LACMIP loc. 10442 [=CIT 1397], hypotype, **51,** pseudofolds of previous varix deep within the aperture ×1¼, **52,** back ×1¼, **53,** apical ×1½, actual aperture position indicated by arrow but the last whorl has been peeled back one-third whorl; **54, 55,** UCLA 39466 from LACMIP loc. 10448 [=CIT 1402], hypotype, **54,** aperture ×1, **55,** ablabral ×1; **56,** UCLA 39464 from LACMIP loc. 10710 [=CIT 1158], hypotype, aperture ×1.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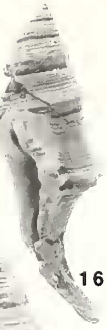
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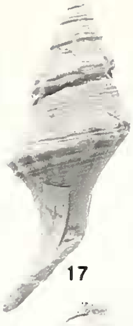
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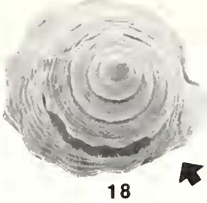
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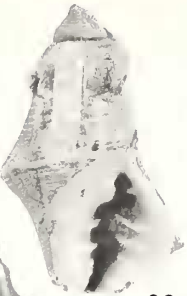
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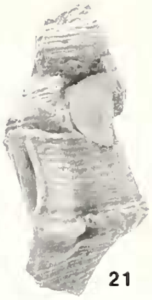
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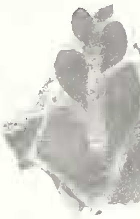
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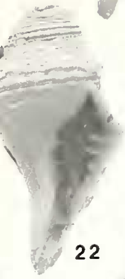
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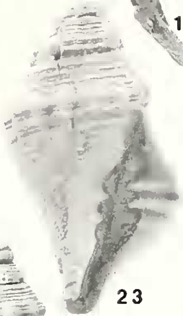
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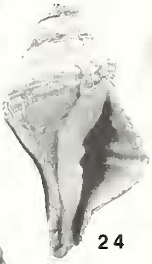
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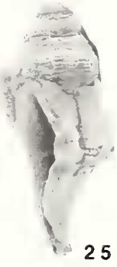
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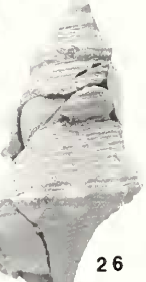
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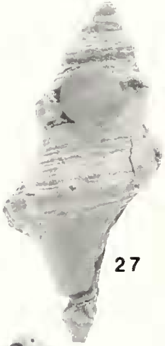
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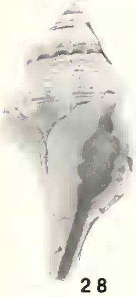
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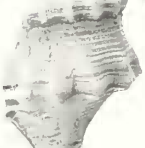
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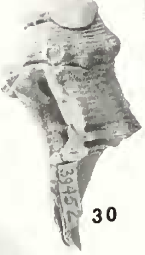
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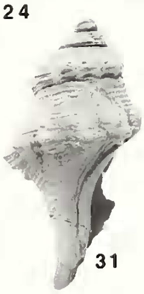
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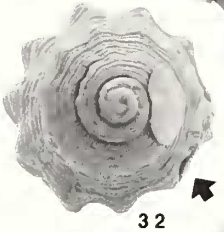
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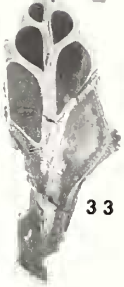
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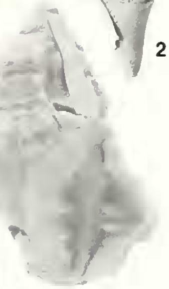
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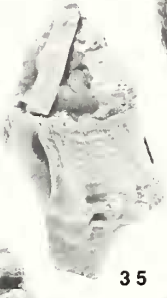
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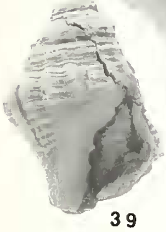
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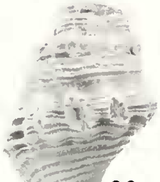
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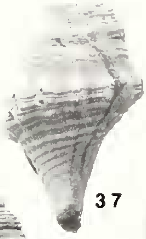
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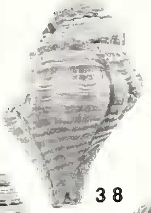
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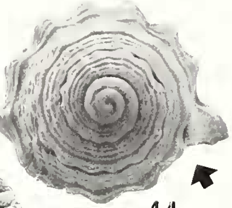
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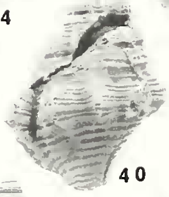
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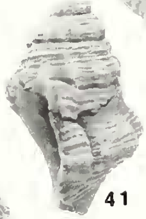
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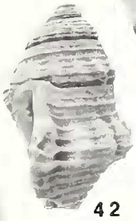
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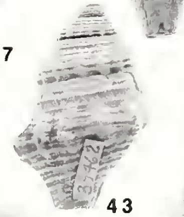
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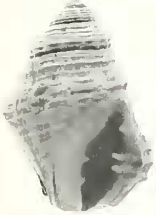
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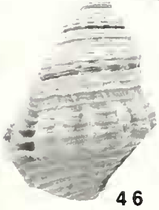
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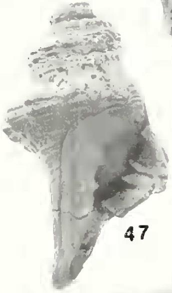
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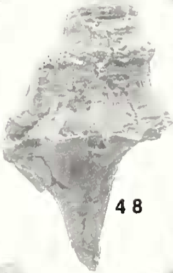
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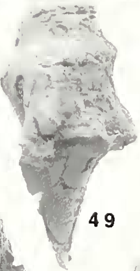
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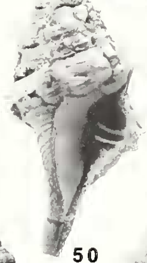
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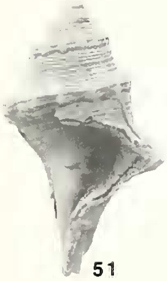
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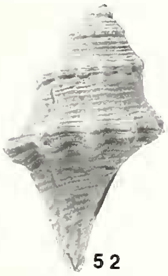
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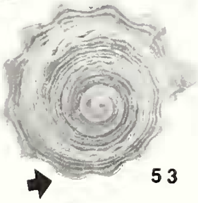
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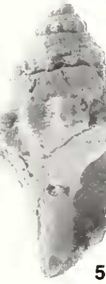
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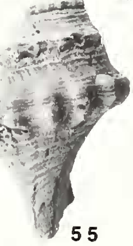
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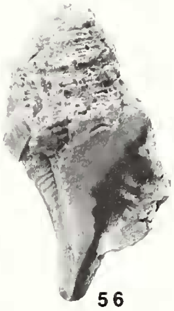
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as wide as interspaces on last whorl, number about doubled by intercalation; axial ribbing apparent on third post-nuclear whorl, strongest at periphery, about 10 on last whorl; adapical of peripheral trio of cords reduced in strength on last third of ultimate whorl.

Aperture elongate, narrow, sharply elliptical; outer lip bearing a denticle near the posterior end; two strong teeth at the periphery alternate with the external spiral cords, and anteriorly an elongate welt which may be somewhat denticulate; inner lip clearly demarked, slightly wider posteriorly with parietal ridge, two strong horizontal pseudofolds opposite the strong teeth of the outer lip, and a welt bordering the anterior canal.

HOLOTYPE. UCLA 39452.

PARATYPES. UCLA 39453 from UCLA loc. 3637 and 39454 from UCLA loc. 3643; LACMIP 7590 from UCLA loc. 3637.

TYPE LOCALITY. UCLA loc. 3637, Chico Creek, Butte Co., California [9].

DIMENSIONS. Of holotype, height 36.2 mm (incomplete), width 18.5 mm, height of spire 13.4 mm, length of siphonal neck 10.5 mm (incomplete).

DISTRIBUTION. Haslam Formation, Benson (=Brannan) Creek and Departure Bay [4]; Ten Mile Member of the Chico Formation along Chico Creek [9], Holz Shale Member of the Ladd Formation, Santa Ana Mountains [16].

GEOLOGIC AGE. Early Campanian.

REMARKS. Despite its considerable geographic range and stratigraphic occurrence through 400 m of the Ten Mile Member on Chico Creek [9], fewer than 20 specimens of *F. baia* have been available for study. Specimens at the top of the Chico Formation on Chico Creek [9] (Figs. 42–46) are intergrades between *F. baia* and *F. popenoei.*

Forsia baia is stouter, has a less bent anterior canal, and has one more cord and fewer nodes at the periphery than *F. lorda.* The suture of *F. baia* has a slightly more abapical position than that of *F. popenoei,* the spire is relatively higher, the ramp is more evenly ribbed, and the peripheral spiral ribs are more variable in strength. On the growth line, the inflection point of the posterior sinus is more posterior than that of *F. lorda* and more anterior than that of *F. popenoei.* Specimens from LACMIP loc. 10093, upper Holz Shale Member in the Santa Ana Mts. [16] are very similar to those from UCLA loc. 3637, lower Ten Mile Member on Chico Creek [9]. The species occurs in the lower *Inoceramus schmidti* Zone of the Haslam Formation along Benson Creek and near Departure Bay, British Columbia [4]. Geologically younger *F. baia* and older *F. popenoei* are very similar and preservation that slightly alters a specimen's shape makes discrimination difficult. A specimen resembling *F. baia* from an unspecified locality on Sucia Island (LSJU loc. 1860) may have come from beds below those yielding *Hoplitoplacenticeras vancouverense* (Meek, 1861). This specimen was, however, certainly not associated with the specimen of *Inoceramus schmidti elegans* Sokolov reported to be from Sucia Island (Anderson, 1958, p. 102, pl. 22, fig. 4; Jeletzky *in* Muller and Jeletzky, 1970, p. 50). The inoceramid does not have an LSJU locality number, and P.U. Rodda (pers. comm., 1985) has found a note with this inoceramid signed by Tatsuro Matsumoto, "I am very sorry to find this specimen in this collection. It is one we sent to Stanford from Japan." The anomalous occurrence of *I. schmidti elegans* on Sucia Island is thus nullified, and there remains no indication that beds of late Santonian or earliest Campanian age are present there, and only the possibility that the top of the Chico Creek section and the lower part of the Sucia Island section are correlative.

Forsia baia resembles *Nekewis washingtoniana* in overall shape and sculpture, but *Nekewis* has a smooth columella and undecorated outer lip, and no specimen of *F. baia* shows the fine collabrally aligned nodes on the ribs mentioned by Hickman (1976). "*Fusus*" *volutodermoides* Nagao, 1939 (Hayami and Kase, 1977, p. 64, pl. 8, fig. 6), resembles *Forsia baia* in shape and sculpture but has fewer nodes about the periphery.

ETYMOLOGY. The specific name is from Greek, *baios,* little, for its occurrence in the Chico Formation along Chico Creek [9].

Forsia popenoei new name

Figures 8, 9, 36–56

Fasciolaria nodulosa Whiteaves, 1874, p. 268, plate of fossils figs. 7, 7a (not 7b; excluded by Whiteaves, 1879, p. 125). Not *F. nodulosa* Emmons, 1858 [*F. nodulosa* Defrance, 1820 (Sherborn, 1922–1932) is a reassignment of *Fusus nodulosus* Lamarck, 1803].

Hindsia nodulosa (Whiteaves): Whiteaves, 1879, p. 125, pl. 15, figs. 6, 7. Whiteaves, 1903, p. 357, pl. 43, fig. 2.

"*Hindsia nodulosa* (Whiteaves)": Popenoe and Saul, 1987, figs. 12, 13.

DIAGNOSIS. Stout *Forsia* with a moderately long arched siphonal neck. Three spiral ribs are stronger on the blunt periphery than are the spiral riblets that cover the shell.

DESCRIPTION. Shell of medium size, subfusiform with turriculate spire of about 3½–4 whorls and slightly flexed anterior canal; protoconch large, paucispiral, consisting of 1–1½ whorls; height of spire is near 0.6 of diameter at periphery; anterior siphonal neck less than ⅓ of shell height, bent near ⅔ length at angle of 30° to columellar axis, with indistinct fasciole; profile of last two whorls usually strongly concave on the ramp, prior whorls flat to convex; peripheral angulation accentuated by three strong spiral cords and made nodose by short blunt axial ribs; suture covering the most anterior of the three strong spiral cords; growth line gently and regularly concave on the ramp and opisthocline across the periphery, broadly convex on the siphonal neck; outer lip flaring medially, and thickened by varix.

Overall sculpture of spiral ribs beginning on first post-nuclear whorl, wider than the interspaces on first whorl, half to a third as wide as interspaces on last whorl, augmented by spiral threads in the interspaces especially on the periphery; axial ribbing apparent on post-nuclear whorls, strongest at periphery, 12–14 on last whorl.

Aperture elongate elliptical; outer lip bearing a strong denticle near the posterior end, two strong teeth at the periphery alternate with the external spiral cords, and a row of denticles anteriorly; inner lip well demarked, somewhat wider posteriorly with denticles which may coalesce into a strong parietal ridge, two strong horizontal pseudofolds, alternate and anterior to the strong teeth of the outer lip, and a somewhat denticulate welt bordering the anterior canal.

LECTOTYPE. GSC 5766, here designated. The Geological Survey of Canada label for GSC 5766 and 5766a refers to Whiteaves' two specimens as hypotypes of *Hindsia nodulosa* (Whiteaves); Upper Cretaceous; Protection Island and 2½ miles up Nanaimo River, Vancouver Island, B.C.; coll. J. Richardson, 1892.

PARALECTOTYPE. GSC 5766a, Protection Island, British Columbia [4].

HYPOTYPES. UCLA 39462 from UCLA loc. 3648 [9], 39464 from LACMIP loc. 10710, 39466–39467 from LACMIP loc. 10448, 39471 from LACMIP loc. 10442; GSC 5767 from Sucia Island [5]; BCPM 1183 from Sucia Island [5].

TYPE LOCALITY. Two and one half miles up Nanaimo River, Vancouver Island, B.C. [4], Canada (Whiteaves, 1874).

DIMENSIONS. Of lectotype GSC 5766, height 22.8 mm (anterior canal missing), diameter 17.8 mm, height of spire 9.8 mm (protoconch missing); of hypotypes UCLA 39466, height 36.4 mm (anterior canal broken at flexure), diameter 22.4 mm, height of spire 15.6 mm; UCLA 39464, height 39.4 mm (incomplete), diameter 22.4 mm, height of spire 15 mm; UCLA 39467, height 37.7 mm, diameter 20.2 mm (crushed), height of spire 11.9 mm, length of anterior canal 11.0 mm (incomplete).

DISTRIBUTION. Cedar District Formation, Nanaimo River and Protection Island [4] and Sucia Island [5]; upper Ten Mile Member of the Chico Formation, Chico Creek [9]; Chatsworth Formation, Bell Canyon, Simi Hills [15].

GEOLOGIC AGE. Late early–mid-Campanian.

REMARKS. Whiteaves (1879) realized that his original combination of *Fasciolaria nodulosa* was a homonym, but as he no longer considered his species to belong in *Fasciolaria,* he saw no necessity for changing the specific name. He therefore referred two of his original specimens to *Hindsia nodulosa.* The original localities are: "Locality No. 4. Nanaimo River, Vancouver Island, 2¼ and 2½ miles up" (Whiteaves, 1874, p. 262), and (p. 263) "Locality No. 5. From Protection Island." As Whiteaves (1879, p. 126) says that two specimens of *H. nodulosa* "were collected by Mr. Richardson in 1872, one from the Nanaimo River, V.I., two and a half miles up, and the other from Protection Island," the original specimen excluded from *H. nodulosa* is the one from 2¼ miles up the Nanaimo River (Whiteaves, 1874, fig. 7b). Both remaining original specimens (Bolton, 1968, p. 105, GSC 5766, and 5766a) were partially cleaned, and the aperture of the specimen from 2½ miles up the Nanaimo River was exposed and the specimen refigured (Whiteaves, 1879, p. 126, pl. 15, fig. 6). The specimens were kept together without indication as to the provenance of each or which was the basis of what figure. Examination under low power (×25) binocular microscope reveals no differences in matrix or preservation of these two specimens. Whiteaves' statements suggest that the syntype with more exposed aperture (GSC 5766) is the one from the Nanaimo River locality, and it is here chosen as lectotype. The Protection Island specimen may be from the Extension–Protection Formation (Muller, fig. 11, *in* Muller and Jeletzky, 1970), and the Nanaimo River specimen from the Cedar District Formation (Jeletzky, p. 52, *in* Muller and Jeletzky, 1970). It is unfortunate that a lectotype must be chosen from specimens of clouded origin when better examples are available with definite geographic and stratigraphic placement.

Both specimens resemble those from the upper *Submortoniceras chicoense* Zone at the top of the Chico Creek section [9] (Fig. 2) as much as Whiteaves' hypotypes of *H. nodulosa* from Sucia Island. One of these hypotypes, GSC 5767 (Whiteaves, 1879, fig. 7), is in the Geological Survey of Canada collection; the specimen collected by Dr. Newcombe (Whiteaves, 1903, pl. 43, fig. 2) which "shows the apertural characteristics unusually well" is in the British Columbia Provincial Museum (BCPM cat. no. 1183).

Forsia popenoei is shorter and stouter than *F. lorda* or *F. baia.* It most closely resembles *F. baia,* from which it differs in being stouter, having the three strong peripheral spiral cords stronger and more persistent, and in having a vanishingly small pseudumbilicus. *Forsia popenoei* resembles some turrids of the subfamily Turriculinae but has a shallower posterior sinus to the growth line and two pseudofolds on the columella. In whorl shape and sculpture it resembles *Nekewis* spp.

Stewart (1927, p. 401) suggested that *Fusus tumidis* Gabb might be related to "*Hindsia nodulosa* Whiteaves," but *F. tumidus* has large swollen nodes on the shoulder overridden by many spiral threads and does not give the impression of angularity of spire and distinctly unequal spiral ribs seen in *Forsia.*

ETYMOLOGY. The species is named for W.P. Popenoe.

Genus *Nekewis* Stewart, 1927

TYPE SPECIES. *Fasciolaria washingtoniana* Weaver, 1912, by original designation.

REMARKS. Stewart provided the name *Nekewis* for ?*Fasciolaria io* Gabb, 1864, *F. washingtoniana* Weaver, 1912, and *Thais nehalemensis* Anderson & Martin, 1914. Gabb (1877, p. 280), while stating that there was no name for the group of ?*Fasciolaria io,* had moved it to *Surcula* (*Surculites*). Stewart (1927, p. 422) included *Nekewis* in the Turridae and characterized it as having a noded shoulder and very shallow anal sulcus. Hickman (1976) reviewed the placement of the genus and considered it a member of the Turridae in the *Acamptogenotia* group. Both Stewart (1927) and Hickman (1976, p. 49) derived it from *Surculites* in the Eocene, and Hickman considered it restricted to the Early Tertiary of the northeastern Pacific. She suggested that the only living relative of *Nekewis* was *Megasurcula,* which has a nontoxoglossate radula (McLean, 1971, p. 119, pl. 2, fig. 43).

Zinsmeister (1983, p. 1299) followed Wrigley (1927) and Powell (1966) in removing *Nekewis* from the Turridae. He placed it in the family Tudiclidae, superfamily Volutacea with *Cophocara* Stewart, 1927, and *Heteroterma* Gabb, 1869, and described a new species *N. simiensis* from the Paleocene of the Simi Valley area [15]. *Cophocara* is a perissityid (Popenoe and Saul, 1987), and if *Nekewis* is confamilial, it too is a perissityid.

Nekewis is most similar to *Forsia,* especially to *F. popenoei,* which it resembles in shape and sculpture. *Nekewis* lacks the aperturual armaments of *Forsia* and has a thinner inner lip. In *Forsia,* the apex of the posterior sinus to the growth line is displaced posteriorly in older to younger species from a peripheral position to one on the ramp (Figs. 5–9), and the sinus is somewhat deeper than that of *Nekewis.* The posterior sinus of the two new species here assigned to *Nekewis* is also somewhat deeper than that of the typical growth line (Hickman, 1976, text-fig. 10). In *Forsia* the posterior end of the growth line is in advance of the anterior portion (Figs. 5–9), but in *Nekewis marina* (Fig. 10) the anterior portion of the growth line is in advance of the posterior, and the growth line is similar to that of many turrids. It is also very similar to that of "*Fusinus* (*Levifusus*)" *waringi* Nelson, 1925. "*Fusinus* (*L.*)" *waringi* resembles *N. marina* and *N. seidersi* except that it has a very long fusinid anterior canal. The depth of the posterior growth line sinus makes placement of these two new species in *Nekewis* somewhat questionable but does not preclude their exclusion from the Turridae. If correctly assigned they extend the record of *Nekewis* back into the Cretaceous.

Nekewis marina new species

Figures 10, 57–61

DIAGNOSIS. Stout *Nekewis* with well-spaced spiral sculpture and an arcuate posterior growth-line sinus that is relatively deep for a *Nekewis.*

DESCRIPTION. Shell of medium size, subfusiform with turriculate spire of about four whorls; diameter at periphery 1.45 times height of spire; profile of last three whorls strongly concave on the ramp, prior whorls flat to convex; peripheral angulation accentuated by three strong spiral cords and made nodose by about 11 short blunt axial ribs; suture covering the most anterior of the three strong spiral cords; growth line concave on the ramp and opisthocline across the periphery.

Overall sculpture of spiral ribs, equal in width to the interspaces on early whorls, one third to a quarter as wide as interspaces on last whorl, ribbing progressively weaker on ramp.

Aperture elongate elliptical; inner lip a little thickened anteriorly, thinning to a wash posteriorly.

HOLOTYPE. LACMIP 7591.

HYPOTYPES. LACMIP 7592 from LACMIP loc. 10667, Ortigalita Peak Quadrangle, Merced Co. [11], and CAS 30553.02 from CAS loc. 30553, Los Baños Creek, Merced Co. [11].

TYPE LOCALITY. UCLA loc. 7149, 2 km south of San Antonio del Mar, Baja California, Mexico [17].

DIMENSIONS. Of holotype, height 29.7 mm (anterior canal missing), diameter 20.5 mm, height of spire 15.6 mm.

DISTRIBUTION. Rosario Formation, south of San Antonio del Mar [17], and the Moreno Formation, Merced Co. [11].

GEOLOGIC AGE. Early and mid?-Maastrichtian.

REMARKS. The above description is based on the holotype which has the anterior canal and the outer lip broken but is otherwise well preserved. Poorly preserved specimens from the Moreno Formation on the east side of the Diablo Range [11], LACMIP 7292 from LACMIP loc. 10667 and CAS 30553.02 from CAS loc. 30553, may also be *N. marina.* A specimen from GSC loc. 16585, east side of Hornby Island [3], has the growth line and sculpture of this species, but is too fragmentary for certain identification. *Nekewis marina* differs from *Forsia popenoei* in having a straight rather than concave whorl profile anterior to the periphery, a thinner inner lip, and no apertural armaments. No varix has been seen on *N. marina.* Shape of and sculpture on the spire of *N. marina* is like that of *N. seidersi,* but *N. marina* is lower spired and more coarsely sculptured. *Nekewis marina* differs from *N. washingtoniana* (Weaver, 1912) (Figs. 67–71) in being stouter, having fewer spiral ribs, and a broader peripheral angulation.

ETYMOLOGY. The specific name is from Latin, *marinus,* of the sea, for San Antonio del Mar.

Nekewis seidersi new species

Figures 13, 62–66

Nekewis new species Saul, 1986, p. 27, figs. 22, 23.

DIAGNOSIS. Stout *Nekewis* with closely spaced spiral sculpture and an arcuate posterior growth-line sinus that is deeper than that of other species of *Nekewis.*

DESCRIPTION. Shell of medium size, subfusiform with turriculate spire of about four whorls, diameter at periphery 1.6 times height of spire; profile of last three whorls strongly concave on the ramp, prior whorls flat to convex; peripheral angulation made nodulose by about 14 short blunt axial ribs; suture near the abapical end of the blunt axials; growth line concave on the ramp and opisthocline across the periphery.

Overall sculpture of spiral ribs, equal in width to the interspaces, faint on the ramp and strong on the periphery.

Aperture elongate elliptical; inner lip a little thickened anteriorly, thinning to a wash posteriorly.

HOLOTYPE. LACMIP 7552.

PARATYPES. LACMIP 7594 from LACMIP loc. 9196; UCBMP 38188 from UCB loc. A-3368, both on Cantinas Creek [12].

TYPE LOCALITY. LACMIP loc. 9196, Cantinas Creek, San Luis Obispo Co. [12], California.

DIMENSIONS. Of holotype, height 32.8 mm (incomplete), diameter 22.8 mm, height of spire 14 mm.

DISTRIBUTION. El Piojo Formation (Seiders, in press) [=part of the Asuncion Formation of Taliaferro (1944)] on Cantinas Creek [12], and possibly basal San Francisquito Formation on Warm Springs Mountain [13].

GEOLOGIC AGE. Late Maastrichtian.

REMARKS. The holotype lacks the protoconch, the end of the anterior siphonal canal, and the edge of the outer lip. Three other specimens from Cantinas Creek [12] are less complete. Three small specimens from Warm Spring Mountain [13] may also be this species. *Nekewis seidersi* is taller and more turriculate than *N. marina*, has finer spiral sculpture, and about three more axial nodes per whorl. *Nekewis seidersi* is shorter than *N. washingtoniana* (Figs. 67–71) and has coarser sculpture.

ETYMOLOGY. The species is named for Victor M. Seiders who collected the holotype.

Heteroterma Gabb, 1869

TYPE SPECIES. By monotypy *Heteroterma trochoidea* Gabb, 1869.

DISCUSSION. The type species of *Heteroterma* differs from other species usually assigned to *Heteroterma* in having a distinctly binodose periphery and in being more biconical in shape. No previously published photograph shows the inner lip and the anterior canal. Gabb (1869, pl. 26, fig. 30) sketched a probable moderately long anterior canal, but Zinsmeister (1983, p. 1298) considered Gabb's reconstructed canal excessively long. Specimens from the lower Santa Susana Formation in the Simi Hills show the inner lip to be rather straight, the anterior canal of moderate length, slightly twisted, fasciolate, and shallowly notched. The growth line is similar to that of *Nekewis* (Figs. 10, 11) and has a posterior sinus on the ramp, and the shell shape resembles that of *Nekewis* but is more shortly biconic and does not have a pagodaform spire. The shape and growth line resemble and could be derived from that of *Christitys* Popenoe & Saul, 1987, or *Pseudoperissitys* Nagao & Otatume, 1938, by narrowing of the periphery. Some forms considered to be *Pseudoperissitys* have a much longer anterior canal than does *Heteroterma;* length of the anterior canal in *Christitys* is unknown. *Christitys* has a fold and pseudofold on the columella and a bifid denticulation within the outer lip; apertural features of *Pseudoperissitys* are unknown.

Heteroterma has been considered to be a turrid by Gabb (1869) and Stewart (1927); Finlay and Marwick (1937) questioned its placement in the Turridae but did not reassign it; Cossmann (1901) and Nelson (1925) placed it in the Turbinellidae; Wenz (1943) listed it under *Pyropsis* in the Vasidae but said that it was insufficiently known and its relationships remained uncertain; Zinsmeister (1983) placed it in Tudiclidae. Zinsmeister commented upon how atypical the distinctive *H. trochoidea* was compared to other species assigned to *Heteroterma;* both *H. gabbi* Stanton, 1896, and *H. striata* Stanton, 1896, combine a relatively shorter spire with a longer anterior canal. The specific identity of both *H. gabbi* and *H. striata* has been confused (Saul, in press). It is to these confounded entities that comparison has been made for assignment of austral species to *Heteroterma* (e.g., Finlay and Marwick, 1937).

Nekewis simiensis Zinsmeister, 1983, is most similar to *H. trochoidea*. It has the conical spire of *Heteroterma* rather than the pagodaform spire of *Nekewis*. Its peripheral sculpture is in two bands as is that of *H. trochoidea,* but in *N. simiensis* the anterior band is weaker and narrower than the posterior band. The sculpture of *N. simiensis* resembles that of *Christitys medica* Popenoe & Saul, 1987, but is more obviously separated into two bands.

Heteroterma? new species of Saul, 1986, of latest Maastrichtian age from Dip Creek [12] is not a *Heteroterma*. Its growth line is suggestive of the Turridae.

Heteroterma trochoidea Gabb, 1869

Figures 12, 72–76

Heteroterma trochoidea Gabb, 1869, p. 152, pl. 26, figs. 30, 30a. Nelson, 1925, p. 427 (in part), pl. 58, fig. 4 only; not figs. 3 & 5 = *Pyropsis* new species Saul, in press. Stewart, 1927, p. 423, pl. 25, fig. 3. Zinsmeister, 1983, p. 1299, fig. 4 (reprint of Gabb, 1869, fig. 30).

DIAGNOSIS. A biconic, peripherally binoded *Heteroterma* with a moderately high spire. The anterior siphonal canal is slightly twisted, fasciolate, and shallowly notched.

DESCRIPTION. Shell of medium size, biconic, with slightly concave-sided spire of about 3½–4 whorls, a narrow, binoded periphery, and an anterior fasciole near the tip of the moderately long anterior canal; protoconch unknown; height of spire about 0.54 of diameter of whorl at periphery, anterior siphonal neck less than one third of shell height; whorl profile concave on the ramp and anterior to the periphery; peripheral angulation accentuated by two spiral rows of blunt nodes; suture on, but not quite covering, the posterior row of nodes; growth line sinused on the ramp and broadly antisinused on the flank.

Overall sculpture of fine, nearly even, spiral riblets, riblets overriding the two spiral rows of blunt nodes which are each on a slightly raised squarish sided spiral band; about 15 nodes per whorl.

Aperture elongate elliptical; inner lip barely thickened.

LECTOTYPE. ANSP 4237 (Stewart, 1927, p. 423).

HYPOTYPES. LACMIP 7596 from UCLA loc. 2330, 7597 from UCLA loc. 2307; UCBMP 30573 from UCB loc. 3776.

TYPE LOCALITY. Near Martinez, Contra Costa Co., California [10].

DIMENSIONS. Of hypotype LACMIP 7596, height 31 mm, diameter 19.9 mm, height of spire 10.7 mm, length of anterior siphonal neck 10.5 mm.

DISTRIBUTION. Vine Hill Sandstone, Martinez area [10]; ?Laguna Seca Formation, east side Diablo Range, Merced Co. [11]; Lower Santa Susana Formation, Simi Hills [15]; San Francisquito Formation, Pinyon Ridge, Rock Creek, Valyermo Quadrangle [14], California.

GEOLOGIC AGE. Late Danian and early Selandian, zone of *Turritella peninsularis*.

REMARKS. The locality and horizon of Gabb's two specimens are unknown. Weaver (1905) and Dickerson (1914) considered *H. trochoidea* to be characteristic of the upper "Martinez" in the vicinity of Martinez, but the species does not appear on Weaver's (1953) Vine Hill Sandstone check list for the Martinez area [10]. Nelson's (1925, pl. 58, fig. 4) specimen is from early in the *Turritella peninsularis* Zone, as are other specimens from the Santa Susana Formation of the Simi Hills [15]. A poorly preserved specimen from UCB loc. A-3262, south of Ortigalita Creek and north of Laguna Seca Creek, Charleston School Quadrangle, Merced Co. [11], in the Laguna Seca Formation is probably this species. Smith (1975) lists *H. trochoidea* from the basal Lodo Formation at the confluence of Silver and Panoche creeks, Fresno Co. [11], but specimens so labeled are *Heteroterma*(?) *acrita* new species. *Heteroterma trochoidea* has a higher spire than *H.*(?) *acrita,* a narrower periphery, a more biconic shell, and the peripheral nodes divided into two spiral bands. None of the well-located occurrences of *H. trochoidea* is younger than the *Turritella peninsularis* Zone.

Heteroterma trochoidea is similar in shape to *Nekewis simiensis* Zinsmeister, 1983, but differs in having the two peripheral bands more nearly equal and flatter topped. The overall fine ribbing is also more even than that of *N. simiensis.*

Heteroterma(?) *acrita* new species

Figures 13, 77–84

Heteroterma gabbi Stanton: Zinsmeister, 1983, p. 1299 (in part), fig. 3Q only (not figs. 3O, P = *H. gabbi* Stanton).

DIAGNOSIS. *Heteroterma* with peripheral nodes not clearly separated into two bands and no anterior fasciole.

DESCRIPTION. Shell of moderate size for the genus, pyriform, low spired; profile concave on the ramp, subangled on both posterior and anterior sides of the periphery, rather straight across the periphery, contracting concavely to form a narrow siphonal neck; suture covering or nearly covering the nodes of the posterior angulation, with a strong subsutural welt; growth line with a shallow antispiral sinus across the ramp, and a broad antisinus across the anterior angulation.

Overall sculpture of fine subequal spiral ribs, finest on the ramp; periphery with about 13 broad, rounded axial ribs, somewhat discontinuous.

Aperture lenticular; outer lip thin; inner lip thin, narrow; columella nearly straight, without folds.

HOLOTYPE. LACMIP 7598.

PARATYPES. LACMIP 7600 from UCLA loc. 2330; UCR 6899/8 and 6899/2; CAS 61666.03 from CAS loc. 61666 [=LSJU loc. 2073].

TYPE LOCALITY. UCLA loc. 2307, Simi Hills, Ventura Co., California [15].

DIMENSIONS. Of holotype, height 25.7 mm, diameter 16.4 mm, height of spire 8 mm.

DISTRIBUTION. Basal Lodo Formation at the confluence of Silver and Panoche creeks, Fresno Co. [11]; lower Santa Susana Formation, Simi Hills [15].

GEOLOGIC AGE. Early and mid-Selandian, zones of *Turritella peninsularis, T. infragranulata pachecoensis,* and early *T. infragranulata.*

REMARKS. Specimens of this species have been confused with *Heteroterma trochoidea* Gabb, *Fusinus waringi* Nelson, and *Pyropsis*(?) *gabbi* (Stanton). Its generic assignment remains equivocal. The shell shape with its concave ramp is suggestive of *Perse* Clark, 1918 [=*Whitneyella* Stewart, 1927]. *Whitneyella* (Stewart, 1927, p. 402) is described as having a single plication on the columella, and *Perse* is placed in the Fasciolariidae. This plication or fold is of varying strength even within a species. In *Perse washingtonianum* (Weaver, 1912), the fold varies from obvious to scarcely discernable, and the absence of a fold is perhaps not the most important criterion for excluding *H.*(?) *acrita* from *Perse.* Despite its other similarities of shape to *Perse,* this species is questionably assigned to *Heteroterma* because of the shape of its columella and aperture. Its lack of a fasciole near the end of the anterior siphonal canal and its thicker, more roundly expanded inner lip are its most notable differences from *Heteroterma* and may ultimately remove *H.*(?) *acrita* from this genus. Assignment of austral species to *Heteroterma* reflects the similarity of shape and sculpture of *H. zelandica* Marshall, 1917, of New Zealand and "*Cominella*" *praecursor* Wilckens, 1907, of southern Patagonia to *H.*(?) *acrita* and *Pyropsis*(?) *gabbi* (Stanton, 1896) rather than to *H. trochoidea.* Comparison with illustrations suggests that *H.*(?) *acrita* is more closely related to these austral species than is *P.*(?) *gabbi.*

None of the specimens of *H.*(?) *acrita* that are at hand has an unbroken outer lip nor does any appear to have a complete anterior siphonal canal. Although always strong, the strength of the subsutural welt is somewhat variable. The spiral rib-

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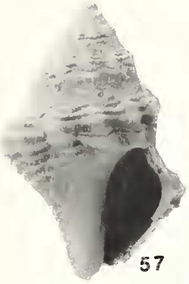
Figures 57–93. Arrow on apical view points at aperture. **57–61,** *Nekewis marina* new species, LACMIP 7591 from UCLA loc. 7149, holotype, **57,** aperture ×1¼, **58,** back ×1¼, **59,** labral ×1¼, **60,** ablabral ×1¼, **61,** apical ×1½. **62–66,** *Nekewis seidersi* new species, LACMIP 7552 from LACMIP loc. 9196, holotype, **62,** aperture ×1, **63,** back ×1, **64,** labral ×1, **65,** ablabral ×1, **66,** apical ×1½. **67–71,** *Nekewis washingtoniana* (Weaver, 1912), LACMIP 7595 from LACMIP loc. 7212, hypotype, **67,** aperture ×1¼, **68,** back ×1¼, **69,** labral ×1¼, **70,** ablabral ×1¼, **71,** apical ×1½. **72–76,** *Heteroterma trochoidea* Gabb, 1869, **72, 74,** LACMIP 7596 from UCLA loc. 2330, hypotype, **72,** aperture ×1, **74,** labral showing outline of outer lip despite loss of shell on last quarter whorl ×1; **73,** UCBMP 30573 from UCB loc. 3776, hypotype, back ×1; **75, 76,** LACMIP 7597 from UCLA loc. 2307, hypotype, **75,** ablabral ×1½, **76,** apical ×2. **77–84,** *Heteroterma*(?) *acrita* new species, **77–80, 84,** LACMIP 7598 from UCLA loc. 2307, holotype, **77,** aperture ×1¼, **78,** back ×1¼, **79,** labral ×1¼, **80,** ablabral ×1¼, **84,** apical ×1½; **81, 82,** CAS 61666.03 from CAS loc. 61666, paratype, **81,** aperture ×1¼, **82,** back ×1¼; **83,** LACMIP 7600 from UCLA loc. 2330, paratype, ablabral ×1½. **85–91,** *Pseudocymia*(?) *wardi* new species, **85, 86,** GSC 91971 from GSC loc. 77447, paratype, **85,** back ×1, **86,** aperture ×1, **87,** apical ×1½; **88–91,** LACMIP 7634 from Puntledge River, Vancouver Island, B.C., holotype, **88,** aperture ×1, **89,** back ×1, **90,** labral ×1, **91,** ablabral ×1. **92, 93,** *Christitys delta* Popenoe & Saul, LACMIP 7646 from LACMIP loc. 8133, hypotype, ×1, **92,** aperture, **93,** labral.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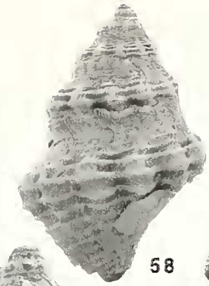
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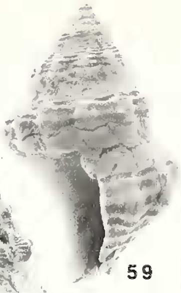
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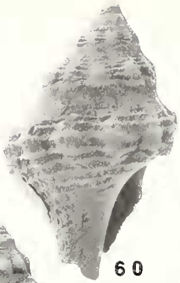
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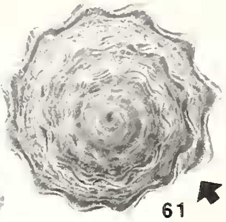
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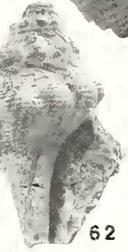
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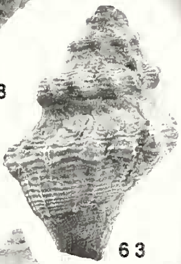
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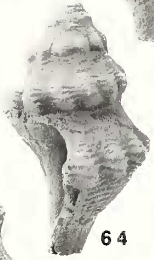
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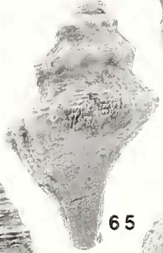
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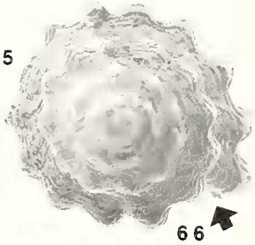
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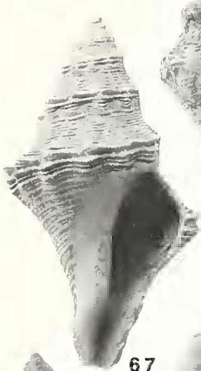
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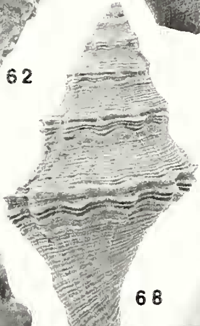
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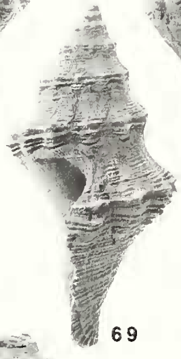
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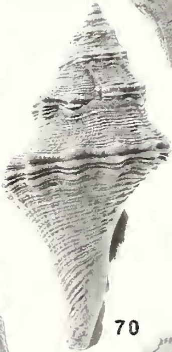
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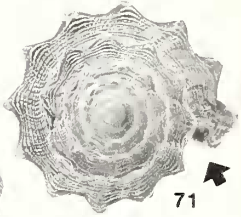
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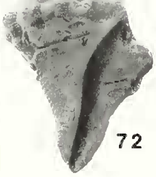
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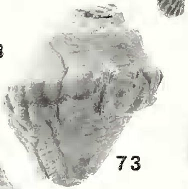
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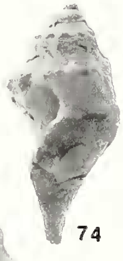
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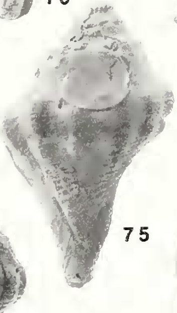
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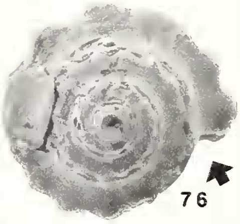
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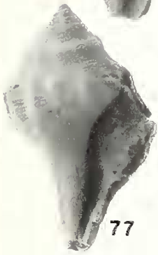
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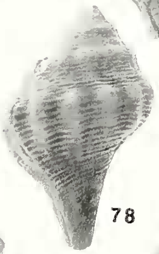
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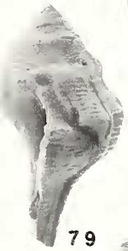
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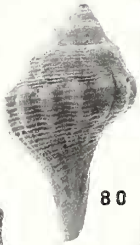
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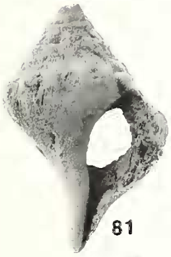
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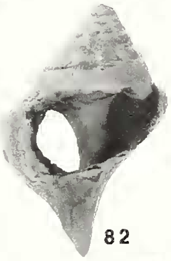
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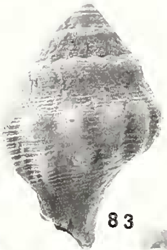
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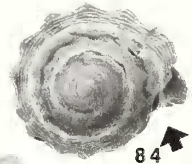
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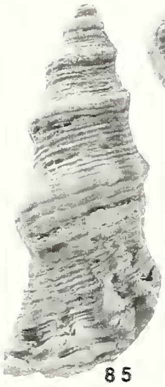
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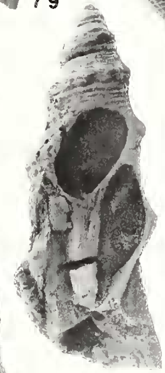
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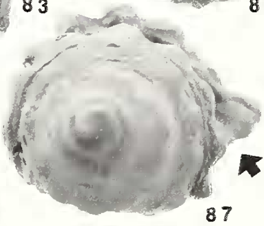
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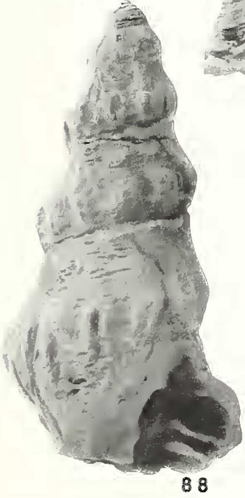
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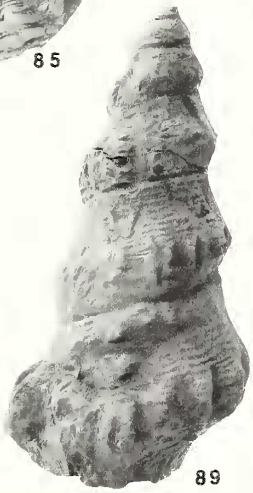
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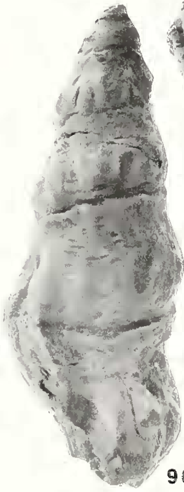
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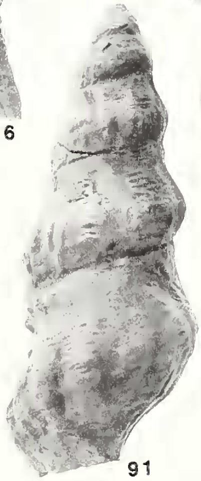
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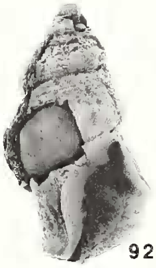
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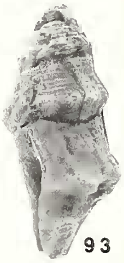
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bing resembles that of *H. trochoidea* in being fine, relatively even, and covering the shell, but is less even than that of *H. trochoidea.* The peripheral axial ribs are commonly somewhat discontinuous and in some specimens have a binodose apsect.

Heteroterma(?) *acrita* differs from *H. trochoidea* in lacking the small fasciole on the siphonal neck, in having a thicker inner lip, and in having the peripheral axial nodes not clearly separated into two bands. It differs from *Fusinus waringi* Nelson in having a shorter, straighter anterior siphonal canal, finer spiral ribbing, and a spire that is not pagodaform. It differs from *Pyropsis*(?) *gabbi* (Stanton) in having a straighter columella, finer, more evenly distributed and graded spiral ribbing, a higher spire, and a more sinuous growth line.

ETYMOLOGY. The species name is from Greek, *akritos,* confused, doubtful.

Genus *Pseudocymia* Popenoe & Saul, 1987

TYPE SPECIES. *Pseudocymia aurora* Popenoe & Saul, 1987, by original designation.

***Pseudocymia*(?) *wardi* new species**

Figures 85–91

Pseudocymia(?) cf. *P.*(?) *aitha* Popenoe & Saul, 1987, p. 29, figs. 119–126.

DIAGNOSIS. High spired *Pseudocymia*(?) with about 12 axial ribs per whorl and flat-topped spiral ribs about the periphery that are wider than the interspaces.

DESCRIPTION. Shell large, fusiform; spire of about five post-nuclear whorls, each about 1½ times as wide as high; apical angle approximately 30°, whorl outline subangular with shallowly concave ramp, peripheral angulation accentuated by short axial ribs; suture just abapical to the periphery.

Sculpture of spiral ribs narrower than the interspaces posterior to the periphery, flat-topped and wider than the interspaces on the periphery; two stronger peripheral ribs on early whorls, at least three on last whorl; periphery made nodulose by about 12 short but strong axial ribs.

Outer lip expanded, bearing a denticle near the posterior end and a pair of strong denticles opposite the periphery; inner lip of moderate width, with a pseudofold opposite the periphery and at least one parietal denticle.

HOLOTYPE. LACMIP 7634.

PARATYPE. GSC 91971 from GSC loc. 77447, Trent River, Vancouver Island [3].

TYPE LOCALITY. Puntledge River, Vancouver Island, British Columbia [3].

DIMENSIONS. Of holotype, height 62 mm (incomplete), diameter at aperture 33.4 mm (27.4 mm behind the varix), height of spire 43.6 mm.

DISTRIBUTION. Haslam Formation on Puntledge and Trent rivers, near Comax [3], Vancouver Island, British Columbia and ?Panoche Formation, Howard Ranch Quadrangle, Merced Co., California [11].

GEOLOGIC AGE. Santonian; the holotype and paratype are from the *Bostrychoceras elongatum* Zone, *Pachydiscus* (*Eupachydiscus*) *periplicatus* Subzone.

REMARKS. *Pseudocymia*(?) *wardi* differs from typical *Pseudocymia* in having a spire that apparently exceeds half of total shell height and in having so few outer lip denticles. It is the slenderest species referred to *Pseudocymia*(?) and resembles *Zinsitys edwilsoni* in spire height but lacks the biangulate whorl profile. The whorl profile of the spire resembles that of *Forsia lorda* and *F. baia* posterior to the periphery, but anterior to the periphery is more convexly rounded. The aperture is incomplete on both available specimens and neither has the anterior siphon preserved. These specimens are most similar to *Pseudocymia*(?) *cahalli,* but they are higher spired and more slender, have a less developed subsutural welt, and have more axial ribs per whorl. The spire and sculpture are well preserved on the paratype, but the holotye provides more of the shell shape.

The specimens identified as *Pseudocymia*(?) cf. *P.*(?) *aitha* by Popenoe and Saul (1987, p. 24) are small and poorly preserved. They have the same number of axial ribs per whorl as *P.*(?) *wardi,* but, perhaps because they are so immature, they have a rounder whorl profile. They also have three rather than two outer lip denticles at the periphery. However, in both specimens of *P.*(?) *wardi* the aperture is damaged and more denticles may be found on more complete specimens.

ETYMOLOGY. The species is named for P.D. Ward who collected and donated the holotype.

Genus *Christitys* Popenoe & Saul, 1987

TYPE SPECIES. *Christitys medica* Popenoe & Saul, 1987, by original designation.

Christitys delta Popenoe & Saul, 1987

Figures 92, 93

Christitys delta Popenoe & Saul, 1987, p. 29, figs. 8, 165–168.

HYPOTYPE. LACMIP 7646 from LACMIP loc. 8133, Oak Run, Millville Quadrangle, Shasta Co., California.

DIMENSIONS. Height 33.5 mm (incomplete), diameter at aperture 29.4 mm, height of spire 16 mm.

DISTRIBUTION. Redding Formation, Hooten Gulch Mudstone, Oak Run [7], Shasta Co., California.

GEOLOGIC AGE. Coniacian.

REMARKS. *Christitys delta* was described from one specimen broken at the anterior end of the aperture providing no information about the anterior siphon. A second specimen, a third larger than the holotype, and with the base of the anterior siphonal canal present, has been discovered. Although incomplete, this specimen suggests that the anterior canal is bent, forming a siphonal fasciole and a pseudoumbilicus. On the last whorl two peripheral spiral ribs become very strong, producing a periphery similar to that of *Perissitys cretacea* (Cooper, 1896), but *C. delta* has a narrower apical angle and a less rounded whorl profile. It resembles *Forsia lorda* new species but has a wider apical angle, the pair of peripheral ribs wider apart, and the bifid denticle slanted more apically.

Genus *Zinsitys* new genus

TYPE SPECIES. *Zinsitys meisteri* new species.

DIAGNOSIS. Elongate bucciniform to spindleform Perissityidae that have a biangulate whorl profile and are slightly flattened in the aperture-to-back dimension. The angulations are noded and the whole shell is spirally ribbed. The growth line is shallowly notched on the posterior angulation. The aperture is eye-shaped and has a well-developed posterior sinus and an anterior sinus of moderate depth. The flared outer lip is slightly thickened and has a bifid denticle well within the aperture between the biangulations. The inner lip is clearly demarked, of moderate width, and has a parietal ridge bordering the posterior sinus.

GEOLOGIC RANGE. Coniacian through Campanian.

DISCUSSION. *Zinsitys* is the most elongate perissityid and has the most biangulate whorl profile. It resembles *Christitys* in having a strong bifid denticulation well within the outer lip; *Pseudocymia* in having a well-marked anterior siphonal fasciole and a siphonal neck that is bent abaperturally; the earliest species *Z. meisteri* resembles *Perissitys cretacea* in having a strong notch in the outer lip on either side of the strong denticulation. *Zinsitys* spp. resemble the volute *Rostellinda dilleri* (White, 1889) in being elongate with a noded shoulder and spiral ribbing. Although *R. dilleri* has an anterior subangulation to the whorl, it lacks the nodes on the anterior biangulation of *Zinsitys* spp. and has stronger, more even spiral ribs, three columellar folds, and no denticulations within the outer lip. *Zinsitys* resembles *Serrifusus* Meek, 1876 (see discussion and figures in Sohl, 1967, p. B29), in sculpture and biangulate whorl, but *Zinsitys,* especially the Campanian species, is more slender. Denticulations have not been described within the outer lip of *Serrifusus.* In shape and sculpture *Zinsitys kingii* (Gabb) resembles *Surculites mathewsonii* (Gabb, 1864) but *S. mathewsonii* lacks columellar pseudofolds and outer lip denticulations and has a somewhat deeper posterior sinus to the growth line. *Zinsitys* spp., however, lose apertural armaments progressively from oldest to youngest species, and *Zinsitys kingii* and *S. mathewsonii* may be related. *Surculites mathewsonii* is usually considered to be a turrid (e.g., Hickman, 1976), but to Wrigley (1939) the growth line of *Surculites* did not appear to be that of a turrid. He suggested that it occupied an indeterminate position between Fusinidae and Buccinidae.

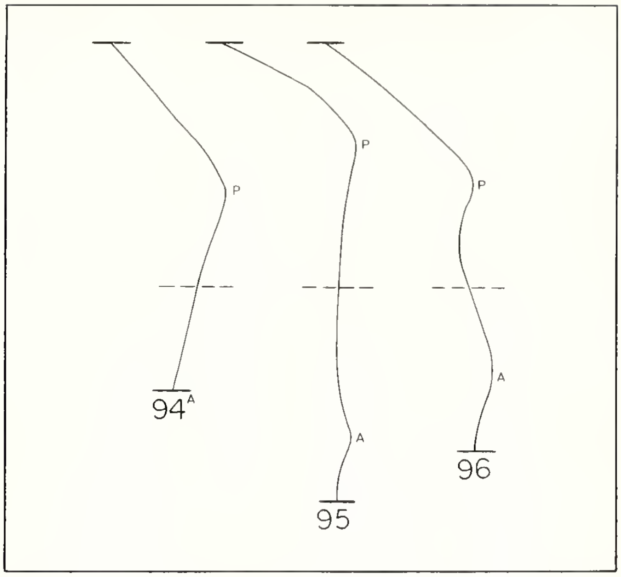
The earliest species of *Zinsitys, Z. meisteri,* is the least elongate, has the most ornamented aperture, including pseudofolds on the columella, and the strongest notches at the anterior and posterior biangulations.

ETYMOLOGY. The generic name is compounded of Zins (for W.J. Zinsmeister) and *itys,* Greek, rim or felly of a wheel.

Zinsitys meisteri new species

Figures 94, 97–101

"*Fusus*" aff. "*F.*" *kingii* Gabb: Popenoe and Saul, 1987, fig. 6.



Figures 94–96. Comparison of posterior portion of growth lines of three species of *Zinsitys* tracings from photographs enlarged and adjusted to uniform distance between posterior suture and the midpoint between anterior and posterior angulations. Heavy lines indicate posterior and anterior sutures, dashed line indicates midpoint between anterior and posterior angulations, P indicates posterior angulation, and A indicates anterior angulation. **94,** *Zinsitys meisteri* new species, the anterior angulation is just anterior to the suture; **95,** *Z. edwilsoni* new species, **96,** *Z. anassa* new species.

DIAGNOSIS. Short *Zinsitys* (the spire height is less than the diameter at the periphery) with only the posterior biangulation exposed on the spire. The columella has two pseudofolds, and the outer lip is well notched at both angulations and is ornamented with denticulations both anterior and posterior to the bifid denticulation.

DESCRIPTION. Shell sturdy, of medium size, stoutly spindleform with shouldered spire of more than four whorls (excluding protoconch), biangulate ultimate whorl, and flexed anterior canal; height of spire (excluding protoconch) is 0.61 of diameter at periphery; anterior siphonal neck less than one third of shell height, bent at the base of the whorl at angle of about 30° to columellar axis, with well-marked fasciole; profile of spire tabulate; profile of last whorl concave on the ramp, concave between the angulations and straight to convex abapical to the anterior angulation; suture covering the anterior angulation on the spire; growth line slightly opisthocline on the ramp, notched at the posterior angulation, barely sinused between the angulations, and slight antisinus anterior to the anterior angulation; outer lip slightly flared basally and thickened by varix.

Overall sculpture of spiral ribs of unequal strength, wider than the interspaces on the early whorls, becoming narrower than interspaces on penultimate whorl; spirals on early whorls made nodular at angulation by about 16 short strong axial ribs; angulations of ultimate whorl with about 11 nodes each.

Aperture elongate; outer lip notched at the angulations, bearing a strong denticle near the posterior end, a small denticle between the anterior notch and the bifid denticle, and a row of small denticles abapical to the anterior notch; inner lip clearly demarked with a posterior parietal denticle and two adapically slanting pseudofolds, the more posterior one about mid lip and barely anterior to the bifid denticle of the outer lip.

HOLOTYPE. LACMIP 7245.

PARATYPES. LACMIP 7601 from LACMIP loc. 10816, 7602 from LACMIP loc. 10842 [=CIT loc. 1223].

TYPE LOCALITY. LACMIP loc. 10816, Oak Run, Millville Quadrangle, Shasta Co., California [7].

DIMENSIONS. Of holotype, height 34.5 mm (protoconch missing), diameter 18.8 mm, height of spire 11.5 mm, length of siphonal neck 10.7 mm.

DISTRIBUTION. Redding Formation; only four specimens have been recognized, two from the type locality in the Hooten Gulch Mudstone on the north side of Oak Run, one from LACMIP loc. 8133 [=CIT loc. 1823] Oak Run, and one from LACMIP loc. 10842 [=CIT loc. 1223], Swede Basin, all in the Millville Quadrangle, Shasta Co., California [7].

GEOLOGIC AGE. Coniacian.

REMARKS. As the stoutest *Zinsitys*, *Z. meisteri* bears the most resemblance to *Serrifusus dakotaensis* (Meek & Hayden, 1856), but even *Z. meisteri* is more slender. Although Erickson (1974) places "*S.*" *vancouverensis* Whiteaves, 1879, in the synonymy of *S. dakotaensis*, *Z. meisteri* is not similar to "*S.*" *vancouverensis* which has a flange-like peripheral keel, very short anterior siphon, and nearly trochiform shape. "*Serrifusus*" *joaquinensis* Anderson, 1958 (excluded from *S. dakotaensis* by Erickson, 1974) is close to, if not identical with, "*S.*" *vancouverensis*.

ETYMOLOGY. The species is named for W.J. Zinsmeister for his contributions to the study of Late Cretaceous and Early Tertiary faunas.

Zinsitys edwilsoni new species

Figures 95, 102–109

DIAGNOSIS. Elongate *Zinsitys* having the whorl profile between the biangulations strongly concave. The outer lip is well notched at the posterior angulation and has within, interior to the anterior angulation, a ridge-like denticle paralleling the bifid denticle.

DESCRIPTION. Shell sturdy, moderately large, spindle shaped with high, shouldered spire of more than four whorls (excluding protoconch), biangulate ultimate whorl, and flexed anterior canal; height of spire (excluding protoconch) 1.63 times diameter at periphery; anterior siphonal neck about one third of shell height, bent at the base of the whorl at an angle of about 20° to columellar axis, with well-marked fasciole; profile of last whorl concave on the ramp, concave between the angulations, and convex abapical to the anterior angulation; suture on but not covering the anterior angulation; growth line slightly opisthocline on the ramp, notched at the posterior angulation, and forming a broad antisinus anteriorly; outer lip flaring basally and slightly thickened by varix.

Overall sculpture of fine spiral riblets of unequal strength narrower than the interspaces; posterior angulation with about 11 strong nodes, anterior angulation with broad rib and nodes, and just abapical to the anterior angulation a second broad rib, nearly equal to the rib on the angulation.

Aperture elongate; outer lip well notched at the posterior angulation and slightly notched at the anterior angulation, bearing a small denticle near the posterior end, a small denticle between the posterior notch and the spirally elongate bifid denticle, and about at the anterior angulation a ridge-like denticle paralleling the bifid denticle; inner lip clearly demarked with a posterior parietal denticle and a low pseudofold just anterior to the strong bifid denticle of the outer lip.

HOLOTYPE. CAS 60172.01.

PARATYPES. CAS 60172.02 from Antelope Creek [8]; CAS 53551.01 from CAS loc. 53551, South Cow Creek [7]; LACMIP 7606 from UCLA loc. 4105, Old Cow Creek [7], California; GSC 87207 from GSC loc. 15616, Brown's River [3], British Columbia.

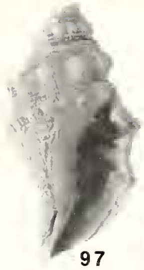
TYPE LOCALITY. CAS loc. 60172, Antelope Creek, Tehama Co., California [8].

DIMENSIONS. Of holotype CAS 60172.01, height 58.2 mm (earliest whorls missing), diameter 22 mm, height of spire 26 mm (earliest whorls missing), length of siphonal neck 19.3 mm; of paratype CAS 53551.01, height 71.5 mm, diameter 22.3 mm, height of spire 36.4 mm.

DISTRIBUTION. Haslam Formation along Brown's River [3] and Elkhorn Creek [4], British Columbia; Redding

→

Figures 97–128. *Zinsitys* spp., all figures ×1 unless otherwise indicated. Arrow on apical views points at aperture. **97–101,** *Zinsitys meisteri* new species, LACMIP 7245 from LACMIP loc. 10816, holotype, **97,** apertural, **98,** back, **99,** labral, **100,** ablabral, **101,** apical. **102–109,** *Zinsitys edwilsoni* new species, **102, 105, 106,** CAS 60172.01 from CAS loc. 60172, holotype, **102,** aperture with crushed outer lip, **105,** ablabral, **106,** apical; **103,** LACMIP 7606 from UCLA loc. 4105, paratype, back; **104,** CAS 60172.02 from CAS loc. 60172, paratype, labral; **107, 109,** GSC 87207 from GSC loc. 15616, paratype, **107,** aperture, **109,** labral; **108,** CAS 53551.01 [=CSMB 14533] from CAS loc. 53551, paratype, specimen with most complete mature aperture. **110–118,** *Zinsitys anassa* new species, **110, 115, 118,** LACMIP 7608 from LACMIP loc. 10446, paratype, **110,** apical ×1.5, **115,** aperture, **118,** back; **111,** LACMIP 7609 from LACMIP loc. 10446, paratype, aperture; **112,** LACMIP 7610 from UCLA loc. 4933, paratype, outer lip cut away to show pseudofold on columella; **113, 114, 116, 117,** LACMIP 7246 from UCLA loc. 7003; holotype, **113,** aperture, **114,** back, **116,** labral, **117,** ablabral. **119–127,** *Zinsitys kingii* (Gabb, 1864), **119, 123,** LACMIP 7612 from LACMIP loc. 10096, hypotype, **119,** ablabral, **123,** aperture; **120,** UCBMP 11965 from Cottonwood Creek, Siskiyou Co., California, holotype, back; **121, 124, 125, 127,** GSC 87206 from GSC loc. 83921, hypotype, **121,** labral, **124,** aperture, **125,** back, **127,** ablabral; **122, 126,** LACMIP 7611 from LACMIP loc. 10715, hypotype, **122,** aperture, **126,** labral. **128,** *Zinsitys*? sp., LACMIP 7643 from UCLA loc. 5028, hypotype, back.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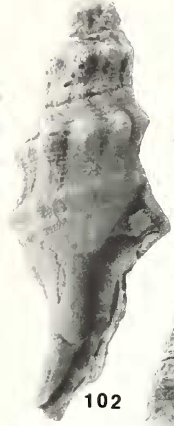
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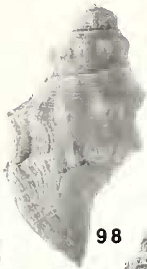
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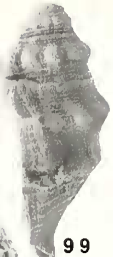
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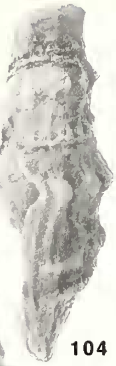
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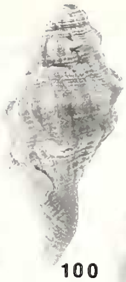
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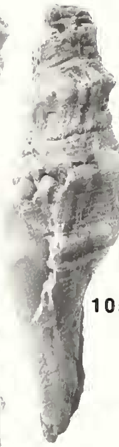
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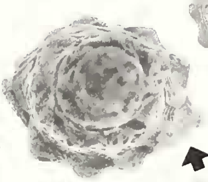
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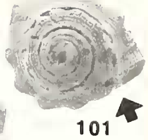
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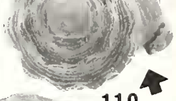
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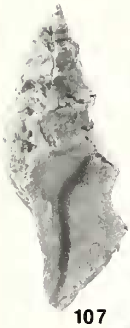
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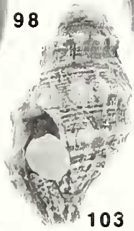
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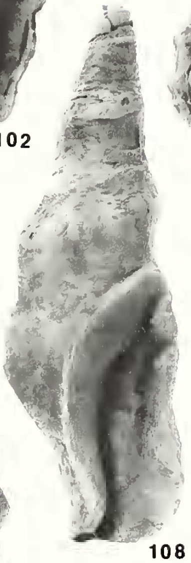
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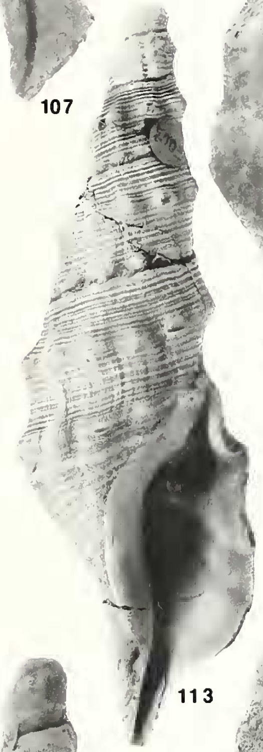
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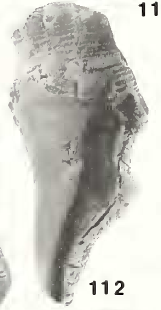
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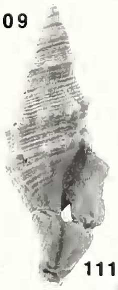
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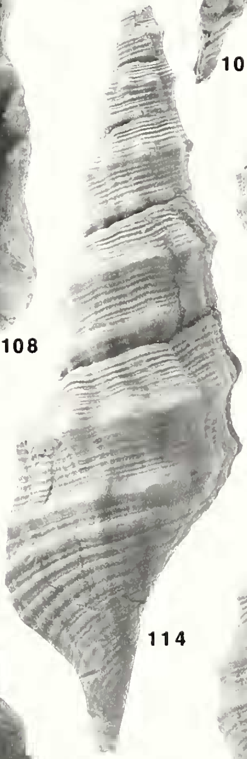
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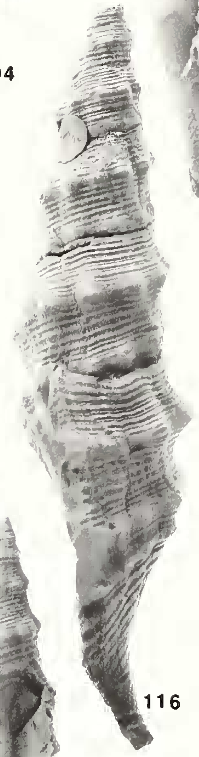
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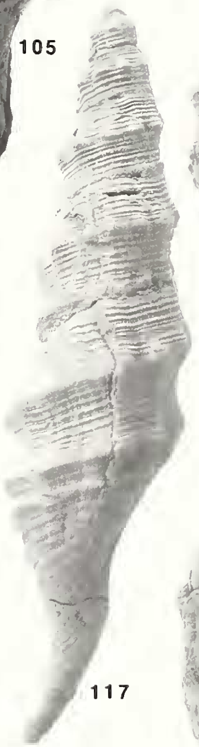
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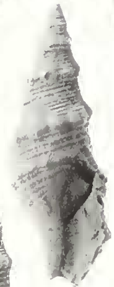
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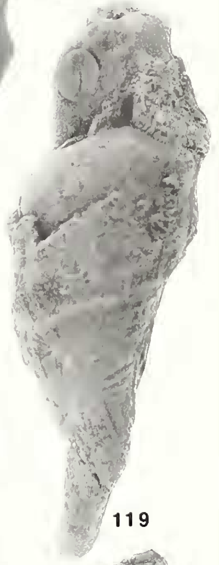
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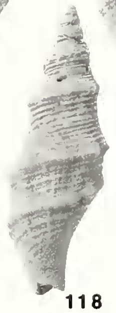
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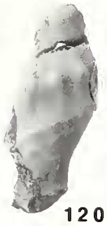
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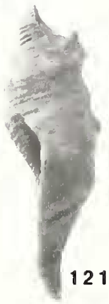
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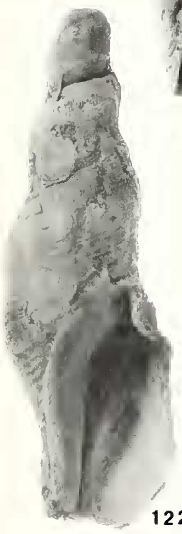
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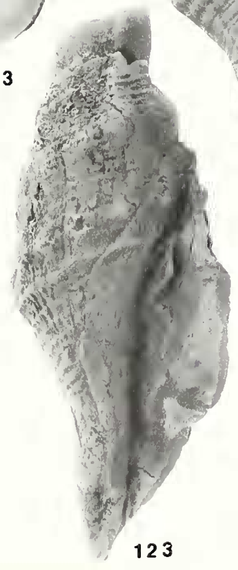
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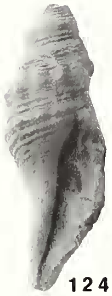
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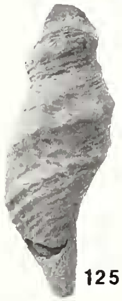
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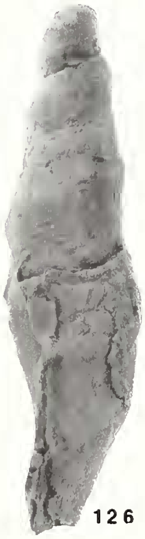
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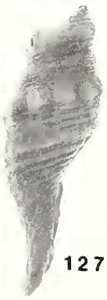
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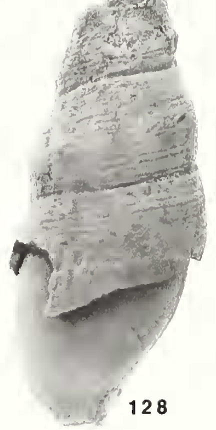
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Formation on Old Cow and South Cow creeks [7]; Chico Formation on Antelope and Mill creeks [8], California.

GEOLOGIC AGE. Santonian.

REMARKS. At hand are three specimens of this species from Vancouver Island and six specimens from northern California. The small specimen (Fig. 103) from the top of Member V on Old Cow Creek (UCLA loc. 4105) [7] is very similar to specimens of *Z. meisteri,* but the nodes of the anterior angulation show just adapical to the suture, a strong rib is present on the ultimate whorl abapical to the anterior angulation, and the shell is slightly more elongate.

Zinsitys edwilsoni is more elongate than *Z. meisteri,* has a more pronounced flare to the anterior portion of the outer lip, and fewer, weaker pseudofolds on the inner lip. The notch at the posterior angulation is proportionately nearer the suture, and the posterior and anterior outer lip notches are farther apart.

ETYMOLOGY. The species is named for Edward C. Wilson.

Zinsitys anassa new species

Figures 96, 110–118

Fusus kingii Gabb: Whiteaves, 1879, p. 119, pl. 15, fig. 4. Whiteaves, 1903, p. 356.

"*Fusus*" cf. "*F.*" *kingii* Gabb: Popenoe and Saul, 1987, figs. 14, 15.

DIAGNOSIS. Elongate *Zinsitys* having the whorl profile between the angulations slightly concave. The outer lip is notched at the posterior angulation, and the columella has only one low pseudofold.

DESCRIPTION. Shell sturdy, large, spindle shaped with high spire of more than five whorls (excluding protoconch), biangulate ultimate whorl, and flexed anterior canal; protoconch large, of about 2½ whorls; height of spire (excluding protoconch) about 1.7 times diameter at periphery; anterior siphonal neck about one fifth of shell height, bent at the base of the whorl at an angle of about 25° to columellar axis, with well-marked fasciole; first post-nuclear whorl convexly rounded; second whorl slightly angled medially; third and succeeding whorls concave on the ramp, angled medially at the posterior angulation, and straight to slightly concave between the anterior and posterior angulations; suture just abapical to the anterior angulation; profile of last whorl concave on the ramp, concave between the angulations, and convex abapical to the anterior angulation; growth line prosocline on the ramp, forming a broad sinus across the periphery and a shallow antisinus across the base, notched at both the angulations, curving into the siphonal fasciole; outer lip flaring basally and slightly thickened by varix.

Overall sculpture of spiral riblets of unequal strength, slightly narrower than the interspaces; first two post-nuclear whorls with spiral riblets only; third and fourth whorls with nodes on the posterior angulation; fifth and succeeding whorls with 10–11 nodes per whorl on both angulations; posterior angulation marked by stronger rib on early whorls, but by fine riblets after the fifth whorl; anterior angulation marked by strong rib, a nearly equal flat-topped rib abapical to the anterior angulation, and three or four additional subequal flat-topped ribs anteriorly on the whorl; siphonal neck with irregularly spaced striae.

Aperture elongate; outer lip notched at the posterior angulation bearing well within a bifid denticle between the anterior and posterior angulations; inner lip clearly demarked with a posterior parietal denticle and a low pseudofold opposite the bifid denticle.

HOLOTYPE. LACMIP 7246.

PARATYPES. GSC 5793 from Sucia Island [5] (Whiteaves' hypotype of *Fusus kingii* Gabb, Bolton, 1965, p. 23); LACMIP 7608–7609 from LACMIP loc. 10446 [=CIT loc. 1400], Sucia Island [5], 7610 from UCLA loc. 7003.

TYPE LOCALITY. UCLA loc. 7003, east end of Little Sucia Island, San Juan Co., Washington [5].

DIMENSIONS. Of holotype, height 99.4 mm (protoconch and three earliest whorls missing), diameter 30 mm, height of spire 51 mm (excluding protoconch and three earliest whorls), length of siphonal neck 21.4 mm; of paratype LACMIP 7608, height 34.9 mm (anterior siphon missing), diameter 13.5 mm, height of spire 19.8 mm.

DISTRIBUTION. Chignik Formation, lower member, at Whaler's Creek (USGS loc. 5795), Alaska Peninsula [1]; Haslam Formation, Elkhorn and Brannan creeks [4] and Cedar District Formation on Sucia Island [5]; Chico Formation at Tuscan Springs [8], Ten Mile Member of Chico Formation on Chico Creek [9], upper Holz Shale Member of Ladd Formation, Santa Ana Mountains [16]. The "lower graywacke" of the Nanaimo Group in the Suquash Basin, northern Vancouver Island [2] has been considered to be correlative to the Cedar District Formation. An immature specimen from southeast of Thomas Point (GSC loc. 83921) may be *Z. anassa,* but because it has comparatively fine nodes on the anterior angulation, it is identified as *Z. kingii.*

GEOLOGIC AGE. Early and mid-Campanian, zones of *Submortoniceras chicoense* and *Hoplitoplacenticeras vancouverense.*

REMARKS. At hand are 22 specimens of *Zinsitys anassa,* more specimens than known for all other species of *Zinsitys* combined. *Zinsitys anassa* is also the most widespread geographically, occurring from Alaska to Orange County, California. The species is most abundantly represented in the Cedar District Formation on Sucia Island [5]. The specimen from the Chignik Formation along Whaler's Creek (USGS loc. 5795), Alaska [1], is incomplete and poorly preserved, but the spire height suggests *Z. anassa* rather than *Z. edwilsoni.* The Chignik Formation is considered to be Campanian (Jones, 1963) based on the occurrence of *Inoceramus schmidtii* and *Canadoceras newberryanum.*

Zinsitys anassa differs from *Z. edwilsoni* in being more elongate, having a less concave whorl profile between the anterior and posterior angulations, a more expanded flare to the outer lip, and fewer ornamentations to the aperture. It differs from *Z. kingii* (Gabb, 1864) in its less concave whorl profile between the anterior and posterior angulation and in having a pseudofold on the columella.

ETYMOLOGY. The specific name is derived from Greek, *anassa*, queen, lady.

Zinsitys kingii (Gabb, 1864)

Figures 119–127

Fusus kingii Gabb, 1864, p. 85, pl. 28, fig. 204.

Not *Fusus kingii* Gabb: Whiteaves, 1879, p. 199, pl. 15, fig. 4. Whiteaves, 1903, p. 356 = *Z. anassa* new species.

DIAGNOSIS. Elongate *Zinsitys* without pseudofolds on the columella.

DESCRIPTION. Shell sturdy, large, spindle shaped, with high spire of more than five whorls, biangulate ultimate whorl, and flexed anterior canal; protoconch unknown, anterior siphonal neck bent at the base of the whorl at an angle of about 10° to columellar axis, with well-marked fasciole; whorl profile barely concave on the ramp with a slight subsutural swelling, angled medially at the posterior angulation and straight to slightly concave between the anterior and posterior angulations, suture just covering the anterior angulation; profile of last whorl barely concave on the ramp, concave between the angulations, and straight to slightly convex abapical to the anterior angulation; growth line prosocline on the ramp, forming a broad sinus across the periphery and a shallow antisinus across the base, curving into the siphonal fasciole; outer lip flaring basally.

Overall sculpture of spiral riblets of unequal strength, slightly narrower than the interspaces; about 10 nodes each on the anterior and posterior angulations, nodes of anterior angulation much the weaker.

Aperture elongate; outer lip notched at the posterior angulation, bearing well within a bifid denticle between the anterior and posterior angulations; inner lip clearly demarked.

HOLOTYPE. UCBMP 11965.

HYPOTYPES. LACMIP 7611 from LACMIP loc. 10715, Dayton Canyon, Simi Hills [15], 7612 from LACMIP loc. 10096, Santa Ana Mountains [16], and GSC 87206 from GSC loc. 83921, near Port Hardy, Vancouver Island [2].

TYPE LOCALITY. "Cottonwood Creek, Siskiyou County, north of Yreka. Named after Mr. Clarence R. King, who, with Prof. Brewer, collected all the fossils brought from this locality" (Gabb, 1864, p. 85); probably from the Hornbrook Formation, Rancheria Gulch Sandstone Beds (Nilson, 1984) [6].

DIMENSIONS. Of holotype, height 27.8 mm, diameter 11 mm; of hypotype LACMIP 7611, height 69.6 mm (incomplete, lacking three early whorls and siphonal neck), diameter 24 mm, height of spire 35.6 mm (lacking protoconch and three early whorls).

DISTRIBUTION. "Lower graywacke" in the Suquash Basin, Vancouver Island [2]; Rancheria Gulch Sandstone Beds of the Hornbrook Formation, Cottonwood Creek, Siskiyou Co. [6]; Chatsworth Formation, Dayton Canyon, Simi Hills [15]; and Pleasants Sandstone Member of the Williams Formation, Santa Ana Mountains [16].

GEOLOGIC AGE. Late Campanian, zone of *Metaplacenticeras pacificum*.

REMARKS. The above description is based upon five incomplete specimens in addition to the holotype. The growth line cannot be traced on any one of them. The most complete mature specimen is from Dayton Canyon [15], but it lacks the earliest whorls and the anterior siphonal neck; its shell surface is poorly preserved, in part due to endoliths (probably mainly boring sponges). The specimen (GSC 87206) from the lower graywacke sequence of the Suquash Basin southeast of Thomas Point (GSC loc. 83921) [2] differs from Sucia Island [5] specimens of *Z. anassa* in having a whorl profile less concave between the two angulations and the anterior angulation much more weakly noded. *Metaplacenticeras occidentale* (Whiteaves, 1889) occurs in an overlying siltstone unit, and Jeletzky (*in* Muller and Jeletzky, 1970, p. 60) suggested that the lower graywacke might be assignable to the *Hoplitoplacenticeras vancouverense* Zone and correlated with the Cedar District Formation. If GSC 87206 is indeed *Z. kingii*, the lower graywacke at GSC loc. 83921 is within the *Metaplacenticeras pacificum* Zone, and the beds correlate with those outcrops of the Cedar District Formation in the Comox Basin [3] which have been recognized as belonging to this zone (Jeletzky *in* Muller and Jeletzky, 1970, p. 70). The regrettable lack of adequate specimens of this species makes its recognition questionable. Based upon available specimens, *Zinsitys kingii* differs from *Z. anassa* in lacking the pseudofold and posterior parietal denticle on the inner lip, in being slightly more elongate, in having the whorl profile less concave between the two angulations, the anterior angulation less strongly noded, and covered by the suture on the spire.

?*Zinsitys* sp.

Figure 128

A specimen from UCLA loc. 5028 (Mt. Chiginagak area [1]) resembles *Zinsitys* in being high spired and having the whorls of the spire angulate. Whether or not the last whorl is biangulate is undeterminable because shell is missing from the anterior half of the last whorl. An impression of two outer lip denticulations positioned as in *Zinsitys* is present on the cast of an earlier whorl. The spiral ribbing is more even and wider than the interspaces, the nodes of the angulation much less well developed, the whorl profile less angulate and less concave than in *Z. meisteri, Z. edwilsoni, Z. anassa,* or *Z. kingii.* The specimen was collected from beds of the upper Chignik Formation in association with *Inoceramus schmidtii* and is probably of early Campanian age. Its spire height is similar to that of *Z. anassa* of similar age, but the angulation on the spire of *Z. anassa* is closer to the posterior suture.

ACKNOWLEDGMENTS

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LOCALITIES CITED

With the exception of type localities, for which complete descriptions are given, previously published localities are abbreviated and the reference is listed. Bracketed numbers key the localities to Figure 1.

[15] 2307 UCLA: E side near crest of spur W of W branch of Meier Canyon, 1.8 mi. SW of 961 B.M., Santa Susana, 3500 ft. SE of hill 1480 in sec. 13, T2N, R17W, Santa Susana Quad., Simi Hills, Calabasas Quad., Ventura Co., Calif. Coll.: Popenoe, 1/9/46. Lower Santa Susana Fm. ?Late Danian or early Selandian.

[15] 2330 UCLA: Nose of spur on NW side Meier Canyon, approx. 3750 ft. S 50°E of 1473 ft. hill, SE¼, SE¼ sec. 12, T2N, R18W, Santa Susana Quad., Ventura Co., Calif. Coll.: W.P. Popenoe, April 3, 1946. Lower Santa Susana Fm. Early Selandian.

[11] A-3262 UCB: About 3.5 mi. S of Ortigalita Creek, Charleston School Quad., Merced Co., Calif. Laguna Seca Fm. Danian (Popenoe and Saul, 1987, p. 35).

[12] A-3368 UCB: Cantinas Creek N½ of NE¼ sec. 8, T23S, R9E, Bryson Quad., San Luis Obispo Co., Calif. Coll.: McCoy, 6/7/40. Asuncion Group. Late Maastrichtian.

[9] 3623 UCLA: E bank Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., lower Musty Buck Member. Santonian (Matsumoto, 1960, p. 155).

[9] 3624 UCLA: First ravine to S of Mickey's Place on W side of Chico Creek about 500 ft. upstream from UCLA 3622 and 100 ft. below fork in ravine, 800 ft. N, 900 ft. E of SW cor. sec. 1, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll.: L.R. & R.B. Saul, 1952. Chico Fm., Musty Buck Member. Early Santonian (Popenoe and Saul, 1987, p. 35).

[9] 3627 UCLA: E bank of Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member. Santonian (Matsumoto, 1960, p. 156).

[9] 3628 UCLA: E bank of Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member. Santonian (Popenoe et al., 1987, p. 99).

[9] 3630 UCLA: W side Chico Creek valley, Paradise Quad., Butte Co., Calif. Chico Fm., basal Ten Mile Member. Late Santonian (Popenoe et al., 1987, p. 100).

[9] 3635 UCLA: E bank Chico Creek, Paradise Quad., Butte Co., Calif. Coll.: L.R. & R.B. Saul, Aug. 17, 1952. Chico Fm., basal Ten Mile Member. Early Campanian (Popenoe and Saul, 1987, p. 36).

[9] 3637 UCLA: E bank Chico Creek, 1250 ft. N, 50 ft. W of SE cor. sec. 14, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll.: L.R. & R.B. Saul, August 18, 1952. Chico Fm., Ten Mile Member. Early Campanian (Matsumoto, 1960, p. 15, 156).

[9] 3639 UCLA: E bank Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Ten Mile Member. Early Campanian (Saul, 1983, p. 121).

[9] 3642 UCLA: W bank Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Ten Mile Member. Early Campanian (Matsumoto, 1960, p. 156).

[9] 3643 UCLA: Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., middle Ten Mile Member. Early Campanian zones of *Submortoniceras chicoense* and *Turritella chicoensis holzana* (Saul, 1974, p. 1093).

[9] 3648 UCLA (=CIT 1183; LACMIP 10861): "Fossil Bluff," W side Chico Creek, 1700 ft. S, 1800 ft. E of NW cor. sec. 35, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll.: L.R. & R.B. Saul, August, 1952. Chico Fm., Ten Mile Member. Late early Campanian.

[15] 3776 UCB: Simi Hills, Ventura Co., Calif. Santa Susana Fm., ?late Danian–early Selandian (Nelson, 1925, p. 440).

[7] 4105 UCLA: Sandstone cropping out at forks of gulch tributary to Old Cow Creek, Jesse Hufford ranch, 2000 ft. S, 2500 ft. W of NE cor. sec. 30, T32N, R1W, Millville Quad., Shasta Co., Calif. Coll: W.P. Popenoe, Aug. 23, 1958. Redding Fm., top of Member V (Popenoe, 1943) = Oak Run Conglomerate Member (Haggart, 1986). Early Santonian.

[7] 4217 UCLA: Bed of Clover Creek, 700 ft. N, 1200 ft. W of SE cor. sec. 22, T32N, R2W, Millville Quad., Shasta Co., Calif. Coll.: Popenoe & Dailey, 1959. Redding Fm., Member VI of Popenoe, 1943; Hooten Gulch Mudstone of Haggart, 1986. Late Santonian (Popenoe et al., 1987, p. 100—as UCLA 4127).

[5] 4933 UCLA: Bluffs southeast end Sucia Island, sec. 25, T38N, R2W, Orcas Island Quad., San Juan Co., Washington. Coll.: T. Susuki, 1962. Cedar District Fm., lowest horizon—just above pebble conglomerates. ?Mid-Campanian.

[1] 5028 UCLA: Near the crest of NW trending ridge extending from Mt. Chiginagak, due north of Mt. Chiginagak, S63°W from Alai, S80°E from Icy Peak, Ugashik Quad., Aleutian Range, Alaskan Peninsula, Alaska. Coll.: W.C. Goth, 1959. Upper Chignik Fm., Early Campanian.

[1] 5795 USGS: Whaler Creek, about 2 mi. from Chignik Lagoon, Alaska Peninsula. Chignik Fm., Lower Member (Martin, 1926, p. 304). Campanian, *Inoceramus schmidtii* Zone (Popenoe and Saul, 1987, p. 36).

[15] 6899 UCR: Simi Hills, Calabasas Quad., Ventura Co., Calif. Santa Susana Fm. Selandian (Zinsmeister, 1983, p. 1303).

[5] 7003 UCLA: East end of Little Sucia (SW islet of Sucia Is.) approx. 200 ft. S from N side of islet and at base of northern E-facing cliff outcrop, sec. 26, T38N, R2W, Orcas Island Quad., San Juan Co., Washington. Coll.: R.B. Saul, 1972. Cedar District Fm., ?just below *Hoplitoplacenticeras*. Mid-Campanian (Popenoe and Saul, 1987, p. 37).

[11] 7044 LACMIP: Fresh road cut E bank of Silver Creek ¼ mi. S of junction with Panoche Creek, Tumey Hills Quad., Fresno Co., Calif. Coll.: Weaver, 1949. Basal Lodo Fm. Mid-Selandian.

[17] 7149 UCLA: Fossils at beach level from sea cliff exposure approx. 2 km S of San Antonio del Mar, Baja California, Mexico. Coll.: Victor Miller, 1984. Rosario Fm. Early Maastrichtian (Popenoe and Saul, 1987, p. 37).

7212 LACMIP (=CIT 812): West bank of Cowlitz River about 2 mi. upstream from toll bridge at Olequah and 3½ mi. E of Vader in sec. 27, T11N, R2W, Lewis Co., Washington. Coll.: Scharf & Popenoe, 9/7/30. Cowlitz Fm. Late middle Eocene.

[7] 8133 LACMIP (=CIT 1823): Oak Run, Millville Quad., Shasta Co., Calif. Coll.: W.P. Popenoe. Redding Fm., Hooten Gulch Mudstone. Coniacian.

[12] 9196 LACMIP: Conglomerate cropping out on east side of Cantinas Creek just (approx. 100 ft.) north of south line of sec. 5, T25S,

R9E, Bryson Quad., San Luis Obispo Co., Calif. Coll.: V.M. Seiders, L.R. & R.B. Saul, Nov. 13, 1985. El Piojo Fm. Early late Maastrichtian.

[16] 10093 LACMIP (=UCLA 4191; CIT 1053): N of Santiago Creek, El Toro Quad., Santa Ana Mts., Orange Co., Calif. Ladd Fm., upper Holz Shale Member. Early Campanian (Matsumoto, 1960, p. 102).

[16] 10096 LACMIP (=UCLA 2326; CIT 1052): Crest of small spur near head of Alisos Creek drainage, about 3750 ft. E of Pankratz Ranch house and 6000 ft. S 8°W of the dam in Harding Canyon, 600 ft. S, 175 ft. W of NW cor. sec. 32 and E edge of topo sheet, T5S, R7W, El Toro Quad., Santa Ana Mts., Orange Co., Calif. Coll.: W.P. Popenoe, Jan., 1933. Williams Fm., Pleasants Sandstone Member, near top of uppermost fossiliferous beds. Late Campanian, *Metaplacenticeras pacificum* Zone.

[5] 10442 LACMIP (=CIT 1397): Float on beach, south side of Fossil Bay near mouth, Sucia Island, Orcas Island Quad., San Juan Co., Washington. Coll.: Durbin, Popenoe, and Popenoe, 7/24/35. Cedar District Fm. Campanian, *Hoplitoplacenticeras vancouverense* Zone.

[5] 10446 LACMIP (=CIT 1400): Sucia Island, Orcas Island Quad., San Juan Co., Washington. Cedar District Fm. Mid-Campanian, *Hoplitoplacenticeras vancouverense* Zone (Matsumoto, 1960, p. 107).

[5] 10448 LACMIP (=CIT 1402): Sucia Island, Orcas Island Quad., San Juan Co., Washington. Cedar District Fm. Mid-Campanian (Popenoe and Saul, 1987, p. 35).

[11] 10667 LACMIP (=CIT 1551): On ridge just above creek bed and near base of sandstone member, 2800 ft. S, 4500 ft. E of SW cor. sec. 33, T11S, R10E, Ortigalita Quad., Merced Co., Calif. Coll.: B.C. Adams, August, 1941. Moreno Fm., Tierra Loma Shale Member. Early Maastrichtian.

[15] 10710 LACMIP (=UCLA 6020; CIT 1158): N bank Bell Canyon, Calabasas Quad., Simi Hills, Ventura Co., Calif. Chatsworth Fm. Late mid-Campanian (Popenoe and Saul, 1987, p. 34).

[15] 10715 LACMIP (=CIT 1159): Prominent fossil bed on crest of spur between forks of Dayton Canyon, about 400 ft. E of Los Angeles–Ventura Co. line, approx. 400 ft. N, 2350 ft. W of SE cor. sec. 28, T2N, R17W, Calabasas Quad., Los Angeles Co., Calif. Chatsworth Fm. Late Campanian (Matsumoto, 1960, p. 103; Popenoe et al., 1987, p. 99).

[7] 10786 LACMIP (=CIT 1005): Near crest of south slope of divide between Basin Hollow and Clover Creek, 2500 ft. S, 2500 ft. W of NE cor. sec. 33, T32N, R2W, Millville Quad., Shasta Co., Calif. Redding Fm., lower Oak Run Conglomerate. Santonian.

[7] 10787 LACMIP (=CIT 1006): Near crest of north slope of divide between Basin Hollow and Clover Creek, 400 ft. S, 2600 ft. W of NE cor. sec. 33, T32N, R2W, Millville Quad., Shasta Co., Calif. Redding Fm., lower Oak Run Conglomerate. Santonian.

[7] 10816 LACMIP (=CIT 1007): Oak Run, Millville Quad., Shasta Co., Calif. Redding Fm., Hooten Gulch Mudstone. Coniacian (Matsumoto, 1960, p. 100).

[7] 10842 LACMIP (=CIT 1223): Small branch of Swede Creek, *Glycymeris* bed, just on the north line of section 8 near the NE cor. of the section, T32N, R3W, Millville Quad., Shasta Co., Calif. Coll.: Popenoe and Ahlroth, 6/30/36. Redding Fm., Hooten Gulch Mudstone. Coniacian.

[9] 10847 LACMIP (=CIT 1016): Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member. Santonian (Matsumoto, 1960, p. 101).

[9] 10849 LACMIP (=CIT 1017): Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member. Santonian (Matsumoto, 1960, p. 101).

[9] 10851 LACMIP (=CIT 1318): Ravine W side Chico Creek, about ½ mi. S of Mickey's Place, N70°W of fire lookout on E wall of canyon and 200 ft. below base of lava beds, lowest fossil bed in gully, thin concretionary layers in soft sandstone, 250 ft. S, 800 ft. E of NW cor. sec. 12, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll.: W.P. Popenoe and Alex Clark, Oct. 24, 1935. Chico Fm., near top of Musty Buck Member. Santonian.

[3] 15616 GSC: On south side of road along Brown's River between diversion dam and overflow outlet, Vancouver Island, British Columbia. Coll.: J.L. Usher, 1945. Sandy shales. Santonian, lower *Bostrychoceras elongatum* Zone.

[3] 16585 GSC: East side of Hornby Island, British Columbia. Coll.: J.L. Usher, 1948. Spray Formation?. Early Maastrichtian?.

[11] 30553 CAS: Los Baños Creek, 1200 ft. E, 1000 ft. S of NW cor. sec. 7, T11S, R10E, Merced Co., Calif. Coll.: G.D. Hanna & J.J. Bryan. Moreno Fm., 2600 ft. above base of *Glycymeris* horizon. Maastrichtian.

[7] 53551 CAS: South Cow Creek, Millville Quad., Shasta Co., Calif. Redding Fm. Santonian.

[8] 60172 CAS (=CAS 61275): Ledge along south side of north fork of Antelope Creek, SW¼, SW¼, sec. 27, T28N, R1E, Panther Spring Quad., Tehama Co., Calif. Chico Fm., Kingsley Cave Member. Late Santonian, *Inoceramus schmidtii* Zone.

[5] 61618 CAS (=LSJU 1860): Sucia Island also northwest islet of Sucia Group, Orcas Island Quad., San Juan Co., Washington. Cedar District Fm. ?Mid-Campanian (Popenoe and Saul, 1987, p. 35).

[11] 61666 CAS (=LSJU 2073): Juncture of Panoche and Silver creeks, Tumey Hills Quad., Fresno Co., Calif. Basal 30 feet of Lodo Fm. Mid-Selandian (Smith, 1975, p. 465).

[3] 77447 GSC: At base of 100 ft. high bluff in the right bank of Trent River and about 270 ft. (90 m) downstream of 50 ft. high falls, Vancouver Island, B.C. Coll.: J.A. Jeletzky, June 24, 1966. Lower Trent River Fm. = Haslam Fm. (Muller and Jeletzky, 1970, p. 5). Late Santonian, *Pachydiscus* (*Eupachydiscus*) *periplicatus* beds.

[2] 83921 GSC: Suquash Basin, east coast northern Vancouver Island, B.C. On the beach below high tide about 1⅛ mi. SE of Thomas Point and opposite the terminal of Port Hardy airport. Approx. 50°40′22″N, 127°22′04″W. Coll.: J.A. Jeletzky, July 29, 1969. Nanaimo Group, Cedar District equivalent. Campanian.

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